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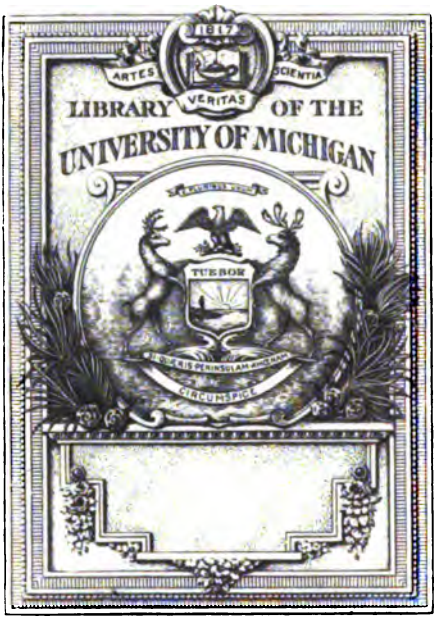
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MODERN

INDUSTRIAL PROGRESS

BY

CHARLES H. COCHRANE

AUTHOR OF "THE WONDERS OF MODERN MECHANISM," "ARTISTIC HOMES, AND HOW TO BUILD THEM," ETC.

WITH NUMEROUS ILLUSTRATIONS

PHILADELPHIA & LONDON

J. B. LIPPINCOTT COMPANY

1904

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PREFACE

We live in a world of wonders, and each one's life is of necessity so hemmed in by circumstances that none can see much beyond the horizon of his own habitat. We recognize the progress of an industry that comes within our own experience, but we know little of those with which we are not in personal contact. The pressman who clamps the plates upon a modern lightning newspaper press does not see anything very startling or interesting in the work; the man who pulls levers in the pulpit of a great steelworks is not apt to recognize that there has been marvellous progress in that line of manufacturing; the attendant on a bottle-blowing machine has learned to take his work as a matter of course—and so we find it through the entire list of trades and occupations. Yet each of these men is at times impressed with the remarkable advances made in some industry other than his own, because such knowledge comes to one, as it were, suddenly, and not by the almost imperceptible movement that marks progress in the work that is familiar.

The means that have brought about industrial development are worth studying. In the eighteenth century England was the one great centre of mechanical progress. She manufactured not only for Great Britain and her colonies, but for practically all other important civilized portions of the globe. Early emigrants to America did not bring with them the tools of their trades, excepting those of the simplest character. The laws of England expressly forbade the exportation of tools and machines for manufacturing, or the taking of skilled workmen to the colonies. Her statesmen desired to retain for Great Britain the position of manufacturer and supply-house for the world. Wise and laudable as was this purpose, from a strictly British point of view, the means employed in the seventeenth and eighteenth centuries to guard England's exclusive position in mechanics and manufacturing were a prime cause of American supremacy in several industries in the nineteenth and twentieth centuries.

For many years the restrictive laws tended to the advantage

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of Britain, but little by little the secrets of machine tools and methods of manufacture extended more and more to the United States, Germany, France, and other countries. The immigrant weaver who sought to follow his trade in the New World a hundred or more years ago, when without a loom built one; the printer who wished to issue a newspaper usually had to construct his own press; the tanner had to make his own vats, and the currier to fashion his own beaming knife and table; and so on through the various trades and arts.

What was the natural result? Necessity quickened ingenuity, and those who thus built from the raw material introduced improvements into the machines that they made for their own use, and, while their first work was usually crude, it often contained the germs of better things than had ever been contrived at the original centre of machine development. It was this lack of imported machines that caused American machine builders to branch out in new lines, resulting in the development of a race of mechanicians that have revolutionized construction in numerous industries, and are largely responsible for bringing about the modern rapid advances in all kinds of machinery and manufacturing processes.

This is why American steel-mills are the wonder of the world; this is why we send more ore through the locks of Sault Ste. Marie Canal, on Lake Superior, than all Europe sends of all sorts of freight through the Suez Canal; this is why we mine coal in Pennsylvania at twice the speed it is taken out at New Castle; this is why American printing machines are used to produce the great newspapers of Europe; this is why American factory-made shoes are worn in China, India, and South Africa; this is why we make tin and terne plate better and cheaper than in Wales; this is why Swiss watches no longer sell in America; and why the cargoes of cut nails that used to sail westward are replaced by cargoes of wire nails that steam to the east.

There is another side to this picture. America has not yet won all the prizes in the industrial world. Her ship-building industry might nearly as well be in the depths of the Pacific. We can hold the America cup at every trial, but we cannot hold a candle beside the beacon lights that illumine the ship-yards on the Clyde. Our native wines sell at half a dollar a bottle, while the foreign article commands four dollars. We can burn out our stomach linings with our own Kentucky whiskey, but we have to go to France and Italy for our light wines. Santos Dumont flew around the Eiffel Tower while our own Langley machine tumbled

into the Potomac. To France we had to go to learn how to build automobiles and to Hungary to learn how to mill flour.

No armed and muscled warrior ever sprang full-grown from his cradle, and no giant industry has ever come into being in a year or a decade. It takes time to develop the machinery and acquaint the world with the advantages of a new aid to manufacturing, commerce, civilization, or human comfort. The signal-fires on Sparta's hills were but the forerunners of Marconi's wireless telegraph. The stone axes of the cave-dwellers were the first types of the wonderful carving and sculpturing machines of the twentieth century. Electricity had its Franklin as well as its Edison. The Damascus blade had to come before the dynamite gun, and Gutenberg with his movable types was needed to lay the foundations for the wonderful presses and machines that roll out our modern mammoth editions of daily newspapers.

It goes without saying that this book is not a complete record of the world's industrial progress, because in the nature of things a single volume does not afford the space for so vast a record. It is only possible to select some of the more prominent industries, and to point out the strides by which they have advanced to their present proportions.

While America is now at the fore of industrial progress in many lines, owing to the conditions described, it is questionable whether she can hope to retain her lead, as many of the causes that led to the upbuilding of our industries are sure to be repeated with increased force in those other quarters of the globe that are opening up to progress and civilization, and which we have been pleased to think of heretofore as benighted regions. He who reads the chapter describing railway progress in Africa, China, Asia, Australia, etc., can hardly fail to be impressed with the idea that no man can measure the possibilities of their industrial growth. Who can say that at the close of the twentieth century Darkest Africa may not be underselling us in our home markets? Who can be sure that in the development of China and the East there may not come an industrial supremacy that shall pale our light? How can we know that there are not now in far-off Australia some prattling Newtons, Faradays, and Roentgens who will paralyze our industries by new discoveries? Perhaps from the hills of old Peru or the broad acres of Brazil may spring new and better conditions that will leave the United States tottering along as a tail-ender in the race.

To-day the industry is exceptional in which there has not been

an entire alteration and renewal in the machinery used within fifteen years. Machines have to be thrown into the scrap-heap more often because they are too slow and out of date rather than that they are worn out. Invention has been stimulated to a degree heretofore unknown, and the rewards obtained by the sale of improved machinery are so great in many cases as to stimulate experiment to a surprising degree, so much so that it has been remarked in more than one field of industry that more money has been spent in trying to improve machines than has been made by their operation.

A preface is usually a word of apology, and, although it takes first position in a book, it is written last. I opine that the reason why the average preface takes the apologetic tone is that the average author at the close of his work comes to feel how inadequately he has performed his task. In my own case it is with mingled feelings of pride for America's position in the world of industry, and regret that I have been unable to present it in more complete and elaborate form, that I lay down my pen and resign this work to the mercies of the reading public.

CHARLES H. COCHRANE.

NEW YORK, December 3, 1904.

CONTENTS

	Page
Electrical Marvels of the Last Decade	17
Electricity for the Million	39
Marconi's Victory over the Ether	50
The Kingdom of Iron and Steel	64
The Conquest of the Air	91
The Evolution in Vehicles and Roadways	118
The Race for Supremacy on the Seas	147
The Tools of Destruction	175
Some Great Canals and Tunnels	194
Great Farms and Farming Machinery	208
The Iron Horse and the Railways	223
The Light of To-day and of To-morrow	254
From Logging-Camp to Planing-Mill	274
In the Bowels of the Earth	292
Modern Foods and Food Preservation	326
How We Obtain Drinking-Water	338
Some Interesting Engineering Enterprises	346
The Art Preservative of All Other Arts	354
The Making of Newspapers and Periodicals	376
The Age of Paper	388
The Wonderful Instruments of Science	400
Bridges—Big, Little, and Peculiar	412
The Machinery of Amusement	426
How Money is Manufactured	441
Machine Tools and Machine Making	449
Progress in Power Producers	461
Cotton, Wool, and Textile Manufactures	483
Revolution in Methods of Glass-Making	495
Tendency of Modern Architecture	502
Flour-Milling by Modern Machinery	517
The Leather and Shoe Trades	527
Rubber and Rubber Goods	538
The Manufacture of Liquors	543
The Tobacco Industry	550
Petroleum and Oil Refining	556
Clay and Its Products	566
Changes in Sugar Manufacture	573
The Furniture Trade	579
The Quarrying Industry	583
Utilization of Factory Wastes and By-Products	588
Garbage and Waste Material	594
Odd and Curious Industries and Mechanisms	602
Minor Miscellaneous Industries	618

LIST OF ILLUSTRATIONS

	PAGE
Portrait ..... *Frontispiece.*	
North America in 1800	xxi
North America in 1900	xxi
Asia in 1800	xxii
Asia in 1900	xxii
Africa in 1800	xxiii
Africa in 1900	xxiii
Australia in 1800	xxiv
Australia in 1900	xxiv
Value of Manufactured Products	xxvi
A 1500 kw. Electric Generator	19
Engine-Room of an Electric-Power Station	23
Burry's Printing Telegraph	26
Murray's Printing Telegraph	27
Electric Sign Flasher	29
The X-Ray and Fluoroscope in Surgery	31
Electric Track-Welding Machine	33
Electro-Magnet for Lifting Pig Iron	34
A Selective Converter	35
Electric Parlor-Car Interior	36
The Parts of a Dynamo	40
Cutting Wheel-Pit for Shafts of the Great Dynamos at Niagara Falls	42
A Three-Unit Balancing Transformer	43
Marconi Wireless Telegraph Stations	51
Diagram of Marconi's Magnetic Detector	56
Iron and Steel Manufacture	65
End View of Steel-Casting Pit, Bethlehem Steel Works	66
Motor Hauling Reheated Blooms to Rail Mill	68
A Steel-Bending Machine	69
Unloading Ore from Steamboat with Brown Conveyors	71
Edison's Magnetic Ore Separator	73
A Solid Ingot of Compressed Steel before Boring	75
Transferring Ore from one Railway to Another	76
Blooming-Mill, showing Ingot on Buggy	77
Wellman Open-Hearth Steel Furnace	78
Wellman Open-Hearth Furnace, Tipped for Pouring	79
Soaking Pits, showing Electric Tongs	80
Tempering a Steel Shaft	81
Flying Shear	83
Flying Shear in a Rail Mill	84
Whitworth Armor-Plate Press	86
A Steel Ingot at the Bethlehem Works	88

PAGE

Cross-Section of Mould for Iron Pipe 89
The Santos Dumont, No. 10 92
Lilienthal's Soaring Apparatus 94
Pilcher's Soaring Machine 95
Chanute's Soaring Apparatus 96
The Whitehead Aeroplane 97
Wright Brothers' Aerostat 98
Lamson's Aerocurve Kite 102
Bell's Four-Celled Tetrahedral Kite 103
Carl E. Myers's Sky-Cycle 104
The Santos Dumont Airship that circled the Eiffel Tower 105
Roze's Aviator, showing Mechanism 107
Steering Mechanism of Roze's Aviator 108
The Cochrane Dirigible Balloon 109
Maxim's Flying Machine 111
Langley's Aerodrome of 1903 113
The Kress Aeroplane 115
A Touring Auto 120
Steel Trackway in New York 122
Carriage Works, Assembling Department 123
Carriage Works, Gluing Department 123
The White Touring Car 128
The Twenty Horse-Power Winton Touring Car 129
Electric Vehicle Company's Runabout 130
Electric Vehicle Company's Runabout, with Mechanism Exposed 130
An Auto-Van 131
Electric Vehicle Company's Auto-Truck 133
Applying Clay to a Sandy Road 135
A Road in Los Angeles before Oiling 137
Same Road in Los Angeles after Oiling 137
A Stone-Crushing Outfit for Road Building 139
Depositing Stone on a Road 141
The Champion Road-Making Machine 142
Ute Pass, Colorado 143
Ouray and Silverton Toll-Road, Colorado 143
Sections of Oiled Road, showing Different Thicknesses of Oil Crust 144
Los Angeles, California, Oiled Road after Three Months' Wear 145
A Newly Finished Oil Road 146
Shamrock III 148
The New Side System of Launching 149
First-Class Battle-Ship Kearsarge, showing Double Turrets 151
First-Class Battle-Ship Iowa 152
Armored Cruiser New York 153
The Steamship St. Louis 154
Diagram of the United States Battle-Ship Connecticut 156
Coaling at Sea 157
The Steam-Yacht Arrow at Full Speed 161
Steamer in Floating Dock 163
Dry-Dock of Detroit Shipbuilding Company 163
A 16,000 Horse-Power Marine Engine 165

PAGE
Crank-Shafts of Ocean Steamship ... 167
Rudder and Propellers of Ocean Steamship ... 168
The Minnesota—Largest American-Built Steamship ... 171
Whaleback in Canal Lock, Sault Ste. Marie ... 173
The Umbrella-Boat ... 174
Submarine Mines and Torpedoes ... 175
A Torpedo in its Tube ... 176
A Submarine Torpedo-Boat ... 177
Holland Submarine Torpedo-Boat ... 178
Burgess's Subsurface Torpedo-Boat ... 179
Old-Time Fort at St. Augustine, Florida ... 181
A Rapid-Fire Gun, with Shield ... 183
The Sixteen-Inch Gun at Sandy Hook ... 184
Diagram showing Mechanism of a Disappearing Gun ... 185
Breech Mechanism of a Large Gun ... 186
Section of Brown Segmental Gun ... 187
Old-Time Wooden Gunboat Vermont, United States Navy-Yard, Brooklyn ... 189
Armor Plates tested by Gunshots ... 190
Springfield Rifle Mechanism ... 192
A Rifle Fitted with a Hyposcope ... 192
The New Magazine Pistol ... 193
High Mine Canal, Platte Cañon ... 194
Irrigation Canal, Stockdale, California ... 195
Locks of Sault Ste. Marie Canal ... 196
Interior of Power-House, Sault Ste. Marie Canal ... 197
A Modern Canal Lock ... 198
Excavating the Chicago Drainage Canal ... 200
A Rock-Drill ... 201
A View in the Simplon Tunnel ... 203
Spree Tunnel, showing Hydraulic Shield ... 204
Tunnelling under East River ... 205
Station in the New York Subway ... 206
The Chicago Tunnel Sewer ... 207
Reaping in a Field of Wheat ... 209
A Six-Disk Steam-Plow at Work ... 213
Apparatus for Studying Soil-Grains ... 215
The Ivel Agricultural Motor ... 218
The Gas-Engine on the Farm (operating a Cream Separator) ... 220
A Telephone Dissected ... 222
A Baldwin Electric Locomotive ... 224
Berlin-Zossen Electric Railway, illustrating Track and Interior of Car ... 225
The Behr Monorail System ... 227
The Baltimore-Washington Monorail System ... 228
Modern Baldwin Passenger Locomotive ... 229
One Hundred and Forty-Four-Ton American Freight Locomotive ... 230
Ballasting a Railway Embankment ... 232
Diagram showing Common Arrangement of Cylinders in a Compound Locomotive ... 233
The Brill Convertible Car ... 235
Railway Tunnel and Embankment, Tomasopa Cañon, Mexico ... 237

PAGE
Constructing an Elevated Railway 238
Goodwin Self-Dumping Cars unloading on a Trestle 240
Elevated Electric Railway at 110th Street, New York 241
Barmen Suspended Railway, showing Turn 242
Barmen Suspended Railway 244
On the Pike's Peak Railway 246
A Compressed-Air Mine Locomotive 247
A Pittsburg Pressed-Steel Car 248
The Hurley Lightning Track-Layer 249
Throwing a Railway Track 250
Block Signal System, Pennsylvania Railroad 251
Front of Switchboard 256
Rear of Switchboard 256
The Nernst Electric Lamp 260
Projector on Mt. Lowe, California 261
Carter Acetylene Generator 262
Colt Acetylene Gas Machine 263
Dellwick-Fleischer Water-Gas Apparatus 265
Sunlight Acetylene Gas Machine 266
Lighthouse Projectors 268
Map of Maine Coast, showing how it is guarded by Lighthouses 270
Fog-Horn Plant on Faulkner Island 272
The Lumber Industry 275
Primitive Lumbering in Kentucky 276
Timber Tract Destroyed by Fire 277
Section of Lumber Flume in "Big Tree" District of California 278
Hauling Logs on a Skidway 280
A Typical Western Lumber-Mill 283
A Single-Saw Resawing Machine 285
A Swing-Saw 286
A Resawing Band-Saw 287
A Saw-Table 288
Wood-Moulding Machine 288
Double-Surfacing Machine 289
Triple-Drum Sanding Machine 289
Fast-Feed Flooring Machine 290
A Mine-Shaft Station at Kimberley 292
Illustrating Method of Boring and Blasting 294
A Steam-Stamp 295
Sand-Pumps 296
A Diamond Prospecting Drill 298
An Electric Mine Locomotive 299
River Dredge Operating for Gold-Bearing Mud 300
Sinking a Small Shaft for Prospecting 302
View in a Silver Mine 303
An Evans' Slime-Table 304
A Harz Gigging-Machine 305
Group of Rotating Screens 307
A Frue Vanner 309
Conical Drum-Hoisting Engine 311

PAGE
A Hooded Safety Mine-Cage ... 312
Landing-Dog ... 313
The "Jubilee" Diamond ... 314
Ingersoll-Sergeant Drills Working in South African Diamond Mine ... 315
Showing Method of Stoping in South African Diamond Mine ... 316
A Washing-Plant in the De Beers Floors ... 318
Diamond Sorter, or "Greaser" ... 319
Jeffrey Locomotive and Mine Car ... 320
British Coal-Fields ... 321
Coal-Miners Working a Longwall Face ... 322
A Modern British Colliery ... 323
A Jeffrey Coal-Cutting Machine ... 324
Cutting Out Tops for Tin Cans ... 327
Salmon Fishery in Portland, Oregon ... 329
Grain Awaiting Shipment ... 331
Discharging Wheat from a Vessel to a Lighter ... 333
Sectional View of the Frick Company's Ice-Making Machine ... 335
McGowan Steam-Pump ... 336
The Deane Artesian Engine and Pump ... 339
Stand-Pipe, Brooklyn, New York ... 341
A Steam-Pump for Large Water-Works ... 343
The New Croton Dam ... 345
Great Nile Dam at Assiut ... 348
Dam at Assouan ... 348
Dam at Spier Falls ... 349
A Sea-Going Dredge ... 350
The Lidgerwood Rapid Unloader ... 351
Shaping the Sides of a Track with Lidgerwood Grading-Machine ... 353
The Press of Gutenberg ... 354
Photo-Engraver's Photographic Apparatus ... 355
Stripping the Plate ... 356
Photographing with Prismatic Reflector ... 357
Pouring on the Collodion ... 358
Whirling the Plate ... 358
Taking a Proof ... 359
The Cottrell Cylinder Press ... 361
The Campbell Company's New Century Press ... 361
The Scott Cylinder Press ... 362
The Scott "All-Size" Rotary Press ... 362
Dexter Automatic Feeder Supplying Sheets to a Printing-Press ... 363
The Linotype ... 365
Lanston Monotype Keyboard ... 366
Lanston Monotype Type-Casting Machine ... 367
Smyth New Model Book-Case Machine ... 371
Smyth Book-Sewing Machine, No. 4 ... 372
Smyth Book-Case Machine ... 373
Rotary Board-Cutter ... 373
Smyth Gluing-Machine ... 374
Dexter Feeding and Folding Machines ... 374
Hoe's Latest Large Color-Printing Newspaper Press ... 378

PAGE
The Autoplate or Automatic Stereotyping Machine 380
Editor Dictating to the Phonograph 383
Composing on the Linotype from Phonograph Dictation 385
Newspapers and Periodicals 387
Making Paper by Hand 388
Logs in the Forest 389
A Log Raft Containing 6,000,000 Feet 390
Hauling Chips to the Paper-Mill 391
The Dilts New Century Pulp-Grinder 393
The Dilts Wet Machine 395
A Log Haul-up at a Lumber-Mill 397
Machine for Reducing the Indian-Corn Plant for Paper-Making 398
Equatorial Telescope, Lick Observatory 400
The "Grande Lunette" Reflecting Telescope 402
The Crossley Reflector 404
Astronomical Observatory, Harvard University 405
Pendulum Experiment for Proving Earth's Rotation 406
Cervenka's Phonograph 408
Marage's Talking Casts 409
Principle of the Bridge Truss 412
Cantilever Bridge at Niagara 413
Halstead Street Tower Bridge, Chicago 414
Comparison of Bridge Towers over East River, New York 417
Spiral Approach to High Bridge, Hastings, Minnesota 419
Washington Bridge, New York 420
Victoria Tubular Bridge, Montreal, Canada 421
Scherer Rolling Lift-Bridge, State Street, Chicago, Illinois 422
Modern Steel Trestle Bridge, Japan 423
Willis Avenue Bridge, New York 424
The Droz Automatons 426
Mechanism of the "Writer" 428
The Puppet Theatre 429
The Floating Lady Trick 432
The Disappearing Lady 434
The Circle of Death 435
The "Sea Serpent" of the Jardin d' Acclimatation 437
Interior of the Sea Serpent 438
A Mint Stamping-Press 442
Annealing Furnaces, Philadelphia Mint 443
Gas-Making Plant of American Gas-Furnace Company at Philadelphia Mint. 444
Cupelling 445
The Melting-Room, Philadelphia Mint 447
Cutting Out Coin Blanks 448
A Modern Lathe with Individual Electric Motor 449
Cincinnati Milling-Machine, with the Crocker-Wheeler Motor 450
A Modern Planer 451
National Machinery Company's Triple-Bolt Cutter 452
An Electric Gantry Crane 453
A Pratt & Whitney Lathe 454
Boring-Machine, Electrically Equipped 455

PAGE
A Sellers Punching-Machine ... 456
Gould & Eberhardt Shaper ... 457
A Niles Boring-Mill ... 459
Westinghouse Compound Steam-Engine ... 463
Warren's Rotary Engine ... 464
Cross-Section of Rotary Engine ... 464
Piston-Wheel of Rotary Engine ... 465
Branca's Steam-Turbine, A.D. 1629 ... 465
De Laval Steam-Turbine ... 466
De Laval 300 Horse-Power Steam-Turbine Motor ... 467
Diagram Illustrating Principle of Westinghouse-Parsons Steam-Turbine ... 468
Waste Water Returning to Niagara River after Furnishing Power to Factories ... 470
Westinghouse Gas-Engine ... 472
The Rand Direct-Acting Steam Air-Compressor ... 473
Large Tandem Stationary Engines ... 474
Hornsby-Akroyd Oil-Engine ... 476
A Mining Engine made in Sections for Transportation on Muleback ... 478
The Pelton Water-Wheel ... 479
De la Vergne Upright Pumping-Engine ... 480
The Los Angeles Sun-Motor ... 482
A Steamer Laden with Cotton ... 484
Mason Manufacturing Company's Loom ... 485
Cotton Machinery ... 487
A Dobby ... 490
Round Cotton-Bale and Press ... 491
Glass-Bottle-Making Machine ... 498
Glass-Cutting ... 500
Fisher's Building, Chicago ... 503
Dufferin Gate, Quebec ... 504
New York Stock Exchange, Interior ... 505
Museum of Art, St. Louis, Missouri ... 506
East Entrance, Capitol at Washington, D. C. ... 507
Flat-Iron Building, Broadway and Fifth Avenue, New York City ... 508
State House, Boston, Massachusetts ... 509
Interior of Library, University of Pennsylvania ... 510
Plymouth Congregational Church, Cincinnati, Ohio ... 511
General Grant's Tomb, Riverside Drive, New York ... 512
Hotel Waldorf-Astoria ... 513
Supreme Court Building, Appellate Division ... 514
150-Ton Rotary Cement Kiln at Edison Portland Cement Company ... 515
Giant Rolls for Breaking Rock in Manufacture of Portland Cement ... 516
Circular Tile Grain Elevators, Minneapolis ... 518
1600-Bushel Grain Scales ... 519
A Roller-Mill ... 520
A Middlings Purifier ... 521
Square Flour-Sifter ... 522
Nordyke and Marmon's Differential Reel for Dressing Flour ... 523
Upright Bran-Duster ... 524
Vaughn Leather-Glazing Machine ... 527

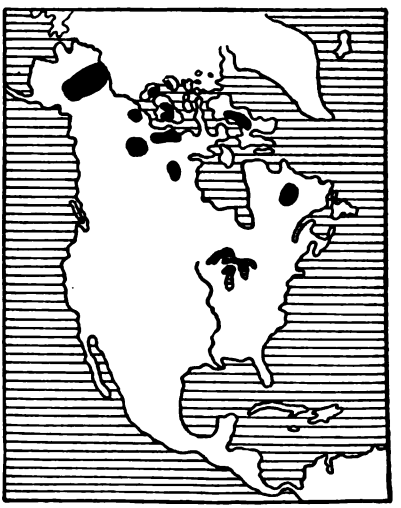
PAGE
Automatic Bleaching-Machine 528
Scrubbing-Machine 530
Vaughn Bark-Cutter 531
Vaughn Pendulum Whitening Machine 533
Belt Knife Splitting-Machine 535
Tapping a Rubber-Tree 538
Curing Rubber 538
View in Rubber Works, showing Calendering Machine 539
Rubber Boot Manufacture 540
Grinding and Cleaning Rubber 541
Varnishing Rubber 541
A Typical Distilling Plant 544
Views in a Brewery 546
Barnard's Water-Cooling Apparatus for Breweries, etc. 548
Duke's Original Factory at Durham, North Carolina 551
The Present Duke Factory at Durham 553
Oil-Derrick in Java 557
Diagram of a Steel Rig for Drilling Oil-Wells 559
Type of Engine Used by Oil Producers 561
A Prospecting Drill 562
Manner of Drilling Oil-Well 564
A Torpedo 564
French Brick-Making Machine 566
Bonnot Pug-Mill 567
German Brick-Making Machine, with Feeder 568
American (Bonnot) Brick-Machine 569
Jeffrey Brick Conveying Machine 570
Hauling Sugar-Cane by Electric Railway in Hawaii 574
Interior View of Standard Beet-Sugar Company at Leavitt, Nebraska 575
Alvarado (California) Factory of American Beet-Sugar Company 576
Centrifugal Machines used in Sugar Manufacture 577
Band Sawing-Machines used by Manufacturers of Furniture 580
Double-End Tenoning-Machine 581
Broaching in Slate with Quarry Bar 583
Ingersoll-Sergeant Track Channeller 584
A Sullivan Channeller at Work 585
Quarrying in Vermont 587
View in Cement Manufactory 589
The Reichhelm Blower, for Ventilating, etc. 591
A Garbage Press 595
Unloading a Garbage Scow 596
View in Baltimore Garbage Reduction Works 598
View in Baltimore Garbage Reduction Works 599
Trolley Bus at Scranton, Pennsylvania 602
Sculpturing Machine beginning Work on Busts 603
Sculpturing Machine making Finishing Cuts on Busts 605
United States Life-Saving Station, Macatawa Park, Michigan 606
Reid's Apparatus for Obtaining Electricity Direct from Coal 608
Fleet of Ice-Yachts 610
A Fire-Ladder 611

PAGE
A Comptometer 612
Pikerdike Letter-Cancelling Machine 613
Mechanism of a Fare-Registering Machine 614
Shaw Electric Crane, Lifting 150-Ton Locomotive 616
View in Lead-Pencil Factory 618
Placing Clothing in the Washer 622
The Drying Closets of a Modern Laundry 623
Mechanism of a Freight Elevator 627
A Vertical Cylinder Hydraulic Elevator 628
The Escalator 629
Telpherage System at a Gas-Works 630
Telpherage System, showing Carriers and Hoist 631
Yoke Riveter making a Government Buoy 632
A Pneumatic Hammer 633
Wire-Drawing Mechanism of the Morgan Construction Company 634
A Wire-Nail Machine 635

INTRODUCTORY

COULD George Washington, who died in December, 1799, have returned to the world in this twentieth century, he would find in America a land comparable with those portrayed in the Arabian Nights, while every other quarter of the globe also scintillated the wonderful progress wrought by the march of what we call industries. It is not the geographers who have changed the maps of the continent as here illustrated, but the mechanics, and manufacturers, and merchants, who,

North America in 1800.

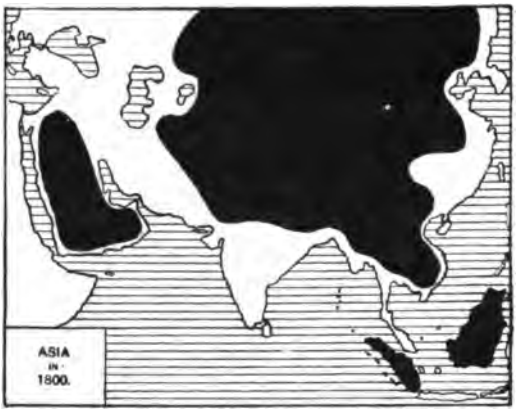


North America in 1900.

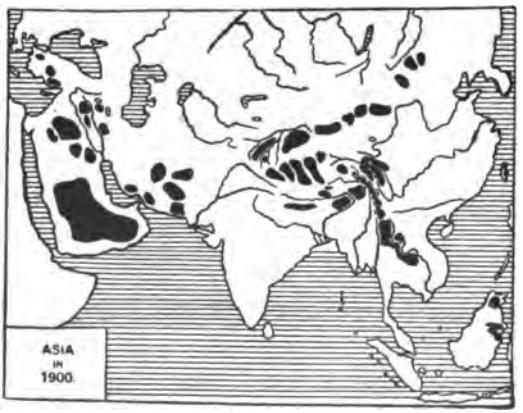
in their efforts to advance their own interests, have built giant industries that have literally altered conditions from pole to pole.

Our Washington did not know what it was to ride in a railway train, or to read a live morning newspaper; he received no telegrams, and wrote his letters with a quill pen; he never slept in a steam-heated room, nor wore a pair of machine-made shoes. Nearly all the things that we of to-day regard as necessities were to him utterly unknown.

But he gave us the chance to make America what it is, the leader of the world's industries, and so we have profited by the foundation-stones he laid, and therefore revere his memory.

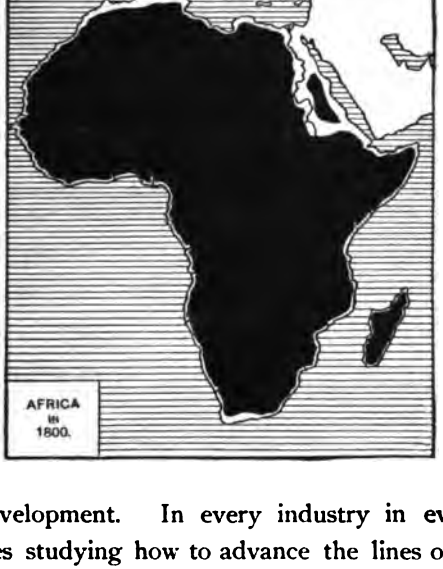


When we look on these maps, and see North America as it was and as it is, Asia as it was and is, and Africa as it was and is, we cannot but realize that the civilization of the world has just begun, and that education is only now reaching out everywhere, with the probable result that all men of all races, all tongues, and all colors will ere long

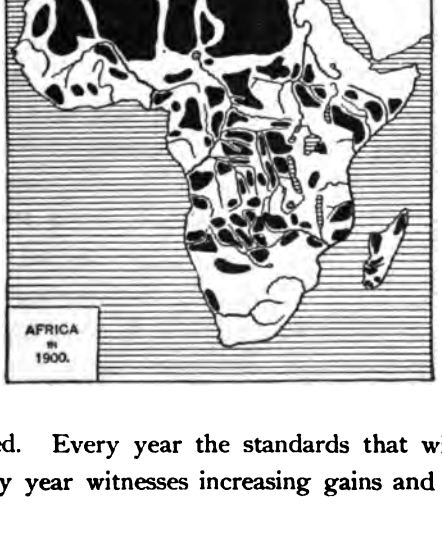


take up their share of progress in industrial science, with results that must prove as marvellous in the future, as the progress of the past would seem to Washington.

It is a tale of manufacturing progress that is not half told, and which never can be told in full, because it grows faster than the ability



to record its development. In every industry in every city on the globe are geniuses studying how to advance the lines of work in which

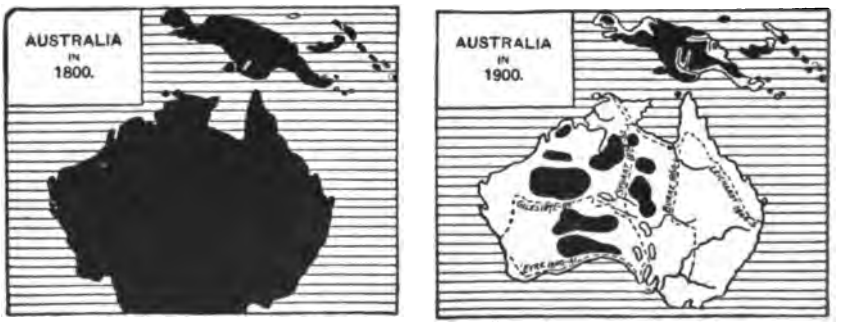


they are engaged. Every year the standards that win success are set higher, yet every year witnesses increasing gains and greater triumphs.

There seems to be no end to industrial progress. The world is full of workers—men who love to work for the sake of the work itself, and these are the ones who contribute to the growth I have attempted to describe in these pages.

America's growth is most marked in the past quarter of a century, because she is the youngest of the great nations. The next quarter of a century may bring the industrious Japanese into the lime-light, or perhaps some South American country may eclipse all records of development.

Some idea of the enormous advances made by the United States during the last half-century may be gleaned by studying the diagram showing the development of manufacturing in the several States. The length of the heavy black lines indicates hundreds of millions of dollars.



For instance, in 1850 New York's gross manufactures for the year amounted to $240,000,000, while in 1900 they totalled $2,175,000,000. All of the older States show amazing increases of this character.

The manufactured goods exchanged by the nations of the world amount to about $4,000,000,000 annually, and the United States contributes about one-tenth of the total. Our exports of manufactured goods doubled between 1895 and 1904, but we are still a long way behind Great Britain, which contributes a fourth of the total, and Germany, which contributes a fifth. Curiously enough, half of the manufactured goods we send out goes to Great Britain, the nation that supplies so many others with manufactured articles.

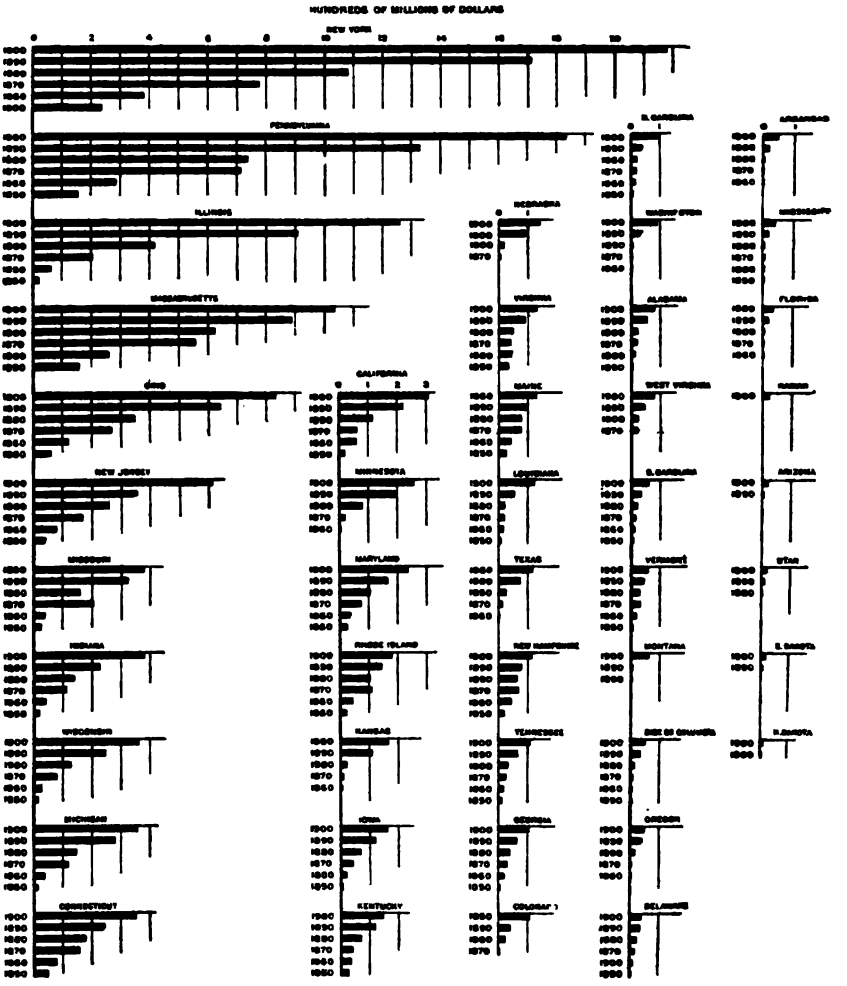
The following table shows the total value of manufactures imported

into and exported out of the leading countries of the world, and the percentage which manufactures form of the total in each case:

Countries.	Imports.	Per Cent. of Mfd. Imports.	Exports.	Per Cent. of Mfd. Exports.
Argentine Republic	$67,717,000	6.81	$704,000	0.4
Australia	156,204,000	76.3	13,754,000	10.2
Austria-Hungary	113,988,000	32.6	187,364,000	48.3
Belgium	104,210,000	23.7	178,840,000	49.9
Brazil	43,020,000	44.8	43,000	. .
Canada	112,506,000	57.3	18,076,000	10.5
Denmark	39,855,000	37.5	3,882,000	4.9
France	212,592,000	24.9	508,803,000	63.2
Germany	366,669,000	28.4	824,051,000	78.1
Italy	101,739,000	36.8	75,373,900	28.5
Japan	69,895,000	51.7	59,902,000	47.0
Netherlands	241,739,000	29.5	231,510,000	33.3
Norway	33,595,000	43.5	12,083,000	28.8
Portugal	23,986,000	39.9	3,366,000	10.9
Russia	158,166,000	56.4	56,069,000	14.5
Spain	57,943,000	37.6	41,330,000	29.0
Sweden	51,835,000	42.0	39,419,000	41.6
Switzerland	93,049,000	42.7	113,111,000	60.1
United Kingdom	725,752,000	28.2	1,076,046,000	77.9
United States	344,816,000	38.2	403,631,030	29.7

In the following pages I have endeavored to outline some impressions as to what has been accomplished in a number of leading divisions of the world's work. They may serve to interest those who have not closely followed the progress of events in particular lines; but in a dozen years from now all that is written here will be an old story, and new inventions and new developments will have shifted the centre of observation to other scenes. It may then be the age of radium, of helium, or of something for which there is not a word coined, because it is not yet known to us.

GROSS VALUE OF MANUFACTURED PRODUCTS OF THE UNITED STATES BETWEEN 1850 AND 1900



MODERN INDUSTRIAL PROGRESS

ELECTRICAL MARVELS OF THE LAST DECADE

ELECTRICITY is believed to pervade the universe. Astronomers see evidence of its action in the sun, in the stars, and in comets. Its properties are so varied, and it affects substances so differently, that it is safe to say that we have as yet learned but a fraction of what mankind is destined to know about this wonderful thing. It comes nearer to being a source of energy or the fabled perpetual motion than anything else in the encyclopædia. Because it so readily lends itself to the transmission of energy, we think of it as a source of power, whereas in reality it is but a means of transmitting power, as are the endless leather belts commonly used to drive machinery. Experience indicates that it can be used for the transmission of almost anything, and that it is possible by electricity to cause a repetition of almost any act at a distance. We can now telegraph through the ether across the Atlantic, and are on the threshold of wireless telephony also, as described in the chapter entitled "Marconi's Victory over the Ether."

As a matter of fact, we do not know what electricity is, and the theories regarding its nature have changed very much within a few years, and unquestionably will be subject to still further revision. Electricians have simply taken the facts about electricity and constructed theories to fit them; as new facts have been learned, the theories have been modified or expanded as the case required.

We know that when a wire is moved about in a magnetic field there is set up an electromotive force. We do not know why this is, but Faraday proved the fact, and all our electric motors and dynamos are based on it. So are our theories, and just as our motors and dynamos are subject to change and improvement as we learn more, so our theories require occasional revision. It is really no great drawback that we have not more fully mastered the nature of electricity. As long as we know how to generate it cheaply, and how to use it to do our work and convey our messages, we are doing very well for mortals with limitations.

The man who thinks he will read up a little on electricity is sometimes very much disappointed because he cannot learn at the outset in a little primer just what electricity is, and so advance step by step to a full knowledge of the subject. But there is no help for it: the student of electricity of this day must begin, as did those who came before, at the other end of the problem, and learn how electricity acts and what it does. After a time he will acquire a notion of things which will satisfy his craving for knowledge, and will cease to bother much about the theory.

So much of modern industrial progress clusters around the one word electricity that it is impossible to treat it all in a single chapter. The larger subjects that are subsidiary to this will be found under other headings, and matters pertaining to electric traction, electric lighting, and wireless telegraphy may be found by consulting the index.

There has been steady progress in the development of standard electrical machinery of all sorts, as dynamos and motors, but the tendency of manufacture in the United States and in Europe is different. In America manufacturers establish certain standard sizes and types of machines in order to make the parts interchangeable. These sizes are carefully chosen and their development systematically studied, with a view to building in large quantities, that the cost may be reduced and broken parts readily replaced. This is the interchangeable system, which is of distinctly American origin, and is generally employed in making machinery of any sort on a large scale in the United States. It would be a perfect system were it not for the drawback that machinery constantly improves, for which no provision exists. The Continental manufacturer of electrical machinery adopts a radically different policy, and constructs his machines according to the demands or specifications of the customer.

Where a customer might call for a six-horse motor wired for a 250-volt current, the American manufacturer would say, "The nearest thing we have is a five-horse motor, unless you take an eight-horse, and both are wired for 220 volts." The Continental manufacturer, on the contrary, would simply book the order and deliver the goods when he got them made. The customer would get exactly what he asked for, but he would pay more and wait longer.

The American method has the advantage that the manufacturer can fill orders for repairs with a certainty and promptness impossible under the Continental method, and can also execute large orders in less time and usually at lower cost. The American plan is rather

more popular with the buying public, as shown by the fact that some foreign companies are adopting it with success. It would undoubtedly replace the Continental plan in time, were it not that there is this strong argument in favor of the latter system: electrical machinery cannot be said to have reached the stage of development attained by the steam-engine or the locomotive.

Courtesy of Electrical World and Engineer.

A 1500 kw. Electric Generator.

The electrical machines of to-day may be in the scrap-heap to-morrow, because something better has been devised that makes it unwise to continue to use the mechanisms that have heretofore served. When changes are called for, the European manufacturer can make them with much greater ease than the American, as the latter may have to throw away a whole line of expensive tools and jigs, fitted to make present machines, but useless for the new ones.

The fact that the American maker is thus tied to existing machines puts a clog on development, and causes him in many cases to resist a tendency to better machines.

Another difference in the manufacture of electrical goods and machinery here and abroad is that the American manufacturer is apt to concentrate his energies on a single class of machines, trying to produce the best of certain styles at the lowest cost, in large quantities, while the Continental manufacturer usually undertakes to make a wide range of machines in one establishment. Here the American system undoubtedly yields the best results, as is commonly the case with specialization. There is also a difference in the systems or customs of finishing electrical goods here and abroad. The foreign manufacturer often puts a fine exterior finish or polish on non-exposed parts, and when his machine is apart it looks much better than the American make. On this side of the Atlantic such finish is regarded as a waste of labor, and seldom or never do manufacturers give a finish to parts that are covered up in the completed article.

Government assistance has been furnished liberally to manufacturers of electrical machinery abroad, while those of the United States have had no such assistance, except as the tariff might protect the home market. Great Britain has its Electrical Standards Laboratory of the Board of Trade, being a department of the government, much as is the Agricultural Bureau in the United States, and it aids the interests of English electrical manufacturers in numerous ways. Very similar is the Central Laboratory of France, where many experiments are carried on which would be impossible or at least impracticable for a single manufacturer. Russia also has a large government electrical laboratory, and the Physikalisch-Technische Reichsanstalt of Germany is famous for its electrical standards of measurement.

Some of the lesser-known discoveries in connection with electricity are quite as marvellous as the sending of messages without wires by Hertzian waves. It is one of the curious things about electricity that every new fact we learn in connection with it seems at first sight to be miraculous. It is not thus with improvements or discoveries in pure mechanics: these are reasoned out and seem natural; but when we stumble on a new fact in the electrical field, it often fills us with wonder akin to awe.

The time is coming when we shall see things a thousand miles away as easily as we now telephone from New York to Chicago. I do not mean that we shall see the things themselves at that dis-

tance any more than we hear the real voices of those who talk to us over the long-distance telephone; but we shall see the representation of what exists or is happening at the other end of the line of communication. Already the way is pointed out. Some years ago Leon le Pontois described a theoretical apparatus for reproducing a scene by electricity, calling it a telectroscope. It was never worked out, but showed the possibility of such an instrument. A number of inventors have succeeded in reproducing crude portraits by telegraphy, though these have never been good enough for commercial reproduction in newspapers.

Edison, Dussard, and others have devoted much time and thought to this interesting field for electricity; but, though all are in agreement that telectroscopy is possible, yet none has hit upon the means of producing it in practice. One of the methods that has been studied, and which may yet yield a practical solution, consists in projecting an image on ground glass and producing reflections in swinging mirrors. The motion of the mirrors is used to vary the strength of electric currents sent to the receiving station, where is located a series of selenium cells, which, being affected by the varying light produced by the varying current, may theoretically reproduce the original picture.

The uses of selenium in connection with electricity constitute a field of remarkable interest. Selenium was discovered in 1817 by J. J. Berzelius, a Swedish chemist, while engaged in the distillation of sulphuric acid and iron. It is classed as a non-metallic element, and in a common form is a lead-gray crystalline mass. If it is heated, the resistance diminishes, but when it is melted so as to liquefy, the resistance suddenly increases. In 1873, May, a telegraph operator of Valencia, discovered that in the crystalline form selenium has less resistance when exposed to the light than in the dark, and it is this quality that has been employed to secure many noteworthy results.

The selenium cell, which is used in many interesting instruments, consists of a sheet or rod of selenium and one of copper included in an electric circuit, which when exposed to the light produces a slight variation in the electric current, because the selenium has become a poor conductor while the copper has remained a good one. Another and the more common form of selenium cell is made by winding a pair of conducting wires about a glass tube. Selenium powder that has been fused is then crowded between the spaces of the wires, and the whole baked at the temperature of boiling water for about twelve hours, by which time the selenium has crystallized

sufficiently to be extremely sensitive to the action of light. The selenium cell made possible that wonderful instrument the photophone, which is a telephone using a beam of light, instead of a wire and an electric current, to connect the transmitter and receiver. In Professor Bell's photophone a vibrating beam of light is allowed to fall on the selenium cell, and as the light vibrates an electric circuit is varied, affecting a telephone receiver. He attached a little silvered concave mirror to the back of a telephone transmitter, and allowed the sunlight (or a strong electric light) to fall on the mirror. By means of lenses the light was concentrated in a small beam and directed towards the receiving instrument, which consisted of a selenium cell and a telephone receiver in circuit with it, a current being supplied by a battery. Thus was accomplished the wonderful result of using a ray of light instead of wires to carry the human voice. When a person spoke into the transmitter, the sound vibrations caused vibrations of the ray of light, and these vibrations of light acted on the selenium cell at the receiver, and set up vibrating currents that caused the diaphragm of the receiver to vibrate just as did the diaphragm in the transmitter, and so the voice was repeated just as when the vibration was caused direct by the electric current carried by a connecting wire in the ordinary telephonic arrangement.

The photophone proved to be of no commercial value, and has remained a scientific toy, but it has been improved upon, securing a combination which utters the spoken message so loud that it can be heard throughout a large room. Instead of an indirect ray of light, there is introduced the " speaking arc," invented by Professor Simon. This speaking arc is obtained by placing a strong arc light in circuit with the transmitter, the alternating current set up by the vibration of the voice in the transmitter being imposed on the direct current of the arc light, and the vibrations of the receiver strengthened, so that it speaks loudly. It is a curious fact that, while the current making the arc light is being varied constantly under this arrangement, yet the eye detects no change in the light, though the promptness with which the current registers the changes at the receiver determines the success of the entire system. This combination of photophone and speaking arc might be employed to reproduce a lecture or speech in some hall distant from where the speaker was located, but there seems to be no demand for anything of the sort, probably because audiences require that a live speaker shall face them and impart life and fire to his remarks by gesture and physical animation.

Turning to the practical side of the selenium cell in its com-

Courtesy Electrical World and Engineer.

Engine-Room of an Electric-Power Station.

mercial use, we find it employed to light buoys automatically in harbors, on coasts, etc., through a mechanism invented by Herr Ruhmer. Buoys are necessary to mark a channel in a harbor, keeping vessels off shoal spots, and they serve a purpose akin to that of a light-house on a rocky or irregular coast. To be of use at night the buoys must bear lights. In times gone by the work of lighting these buoys was very tedious, requiring a boat to visit them regularly. Where buoys are numerous, as in New York harbor, wire connections for electric lighting are practicable; but where the buoys are at considerable distances, the selenium device has been a great boon. In this most interesting mechanism the darkness itself is utilized to light the gas-lamps of the buoys.

Such buoys are usually lighted by gas under pressure, as in the Pintsch light commonly used on railway trains. In clear weather such a light is visible about six miles away, and serves to warn vessels off a point where a light-house is impracticable. Before the selenium device came into use each light-tank was supplied with as much gas as practicable, and it was allowed to burn until it went out or an attendant came along and replenished the gas. With the introduction of the selenium cell for automatically shutting off the gas during the hours of daylight, the time that the gas lasts is doubled. As soon as the dawning day brings enough light to act on the selenium cell of a buoy, its resistance is reduced and a magnet brought into operation that closes the gas-valve; and at nightfall, when the deepening shades increase the resistance, the current is reduced, and by means of a relay a magnet operates in the other direction, opening the gas-valve. The light may either be turned down low, or it may be turned out altogether, and ignited by an electric spark.

A burglar-alarm, one of the best made, owes its existence to the selenium cell, and the typical dark lantern of the burglar is made his undoing, or if he lights the gas down-stairs, when he imagines all are safely asleep above him, off goes a big gong and up blazes every other gas-jet in the house.

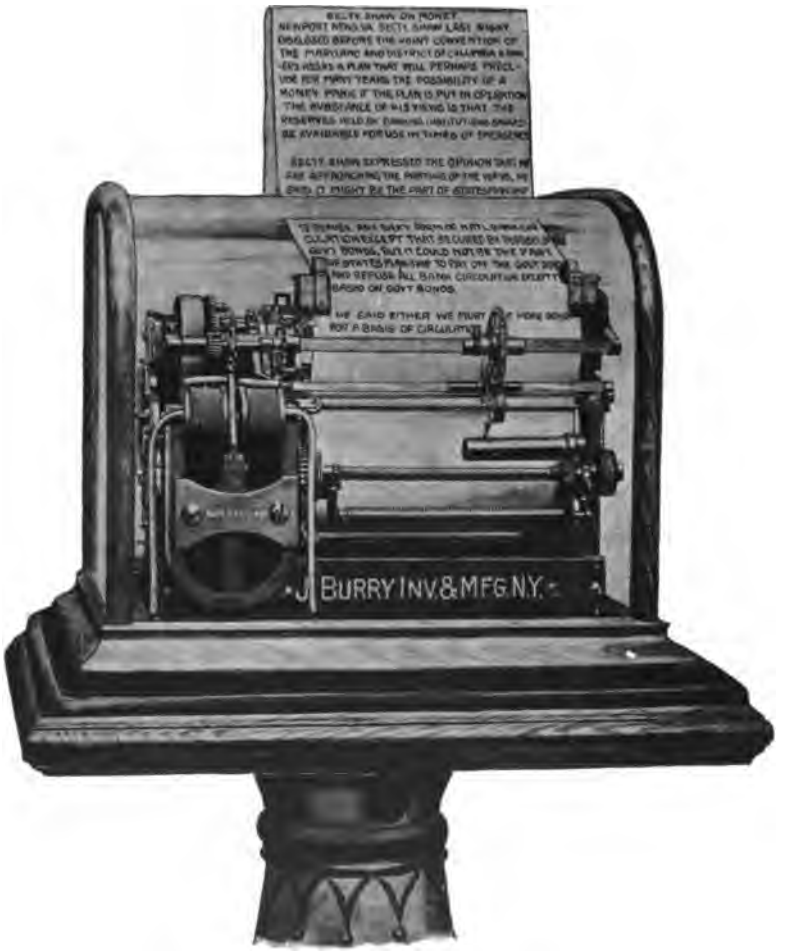
The selenium cell is so much quicker than the eye in noting the action of light that it has been employed to observe an eclipse and make a record of light changes beyond the ability of the eye to follow. Professor Barnard, of the Lick Observatory, in California, has employed selenium in a device for automatically detecting comets, the theory being that when the telescope was pointed into a field where there was a comet, the increased light would affect the selenium so promptly and surely as to be manifest electrically with greater ease than it could be visually at the eye-piece.

A method of ore-finding by electricity has met with some success in California, Alaska, and Wales. It was devised by Leo Draft and Alfred Williams, and with it they have successfully located and mapped out a number of metalliferous deposits which had failed of detection in any other way, notably a lost vein of a lead-mine owned by H. Gamman, in Wales. The system consists in placing two electrodes in the ground at some distance apart, these being connected with an apparatus for generating electric waves. An interrupter breaks the earth-connection 700 times a minute, while the breaks are heard in a resonator. The prospector shifts his earth-connections from place to place, and when he is directly over a lode of metal ore the noise in the resonator is the loudest. The system is valuable as an aid to the prospector, rather than as a sure thing for finding valuable deposits. It will show the same results for an iron pipe under ground as for an ore vein, and even a stratum of wet earth or a subterranean stream may produce the same noises as the desired vein. Therefore the apparatus requires to be used by competent prospectors, who also make use of the older methods of judging where deposits are likely to be found.

The fact that the telegraph uses an alphabet of its own, which is understandable only to those who know the Morse code of dots and dashes, has led to many endeavors to substitute a mechanical means of rendering messages in ordinary printed characters. Inventions having this object in view are called printing telegraphs, and a vast number of patents have been granted for such, most of which have failed of general use because of the complexity of the mechanism. A few simple ones have been developed, however, which it is of interest to consider. It will be recognized that if a receiving telegraph instrument, instead of punching little holes in a paper tape, registers them after the fashion of a typewriter on a neat sheet of paper, many advantages accrue, besides the one of allowing anybody to read it who can read print. It avoids the chance of clerical error in copying the message after receipt, and it permits numerous copies to be made automatically, all of which must be exact copies of the message sent, the chance for error being confined to the individual who sends the message originally.

The printing telegraph of John Burry, of New York, uses two line wires, and by the manipulation of a keyboard impulses may be sent to any number of receiving machines, where the message will be automatically printed in sheet form in capital letters. (See illustration.) It is obvious that such a printing telegraph has uses far beyond those of a telegraph company. The broker, who is in the

habit of receiving numerous telegrams daily, simply installs a machine in his office, and in come the messages ready printed in the machine, with no delay for delivery. The printing wheel, bearing the rubber type, is much like the type-wheel of some typewriters,



Burry's Printing Telegraph.

except that it slides sideways along the rod in front of the paper, while the paper is stationary, except when reeled up a space for a new line. Something like a thousand of these ingenious little printing telegraphs have been placed in use. The mechanism is operated entirely by magnets, so that the user has only to connect it properly

with an electric current, and to keep it in order and supplied with paper, to enable it to do its work automatically.

The printing telegraph of Professor Henry A. Rowland, of Baltimore, consists of a sender having keys like a typewriter, on which the message is written. An alternating current of constant frequency is passed over the line to operate synchronous motors. The different characters are obtained by the suppressing of various combinations of half waves of the current. The receiving instrument has a type-wheel that prints the message on a sheet of paper, the wheel rotating continuously, and being pressed against the paper

Murray's Printing Telegraph.

the instant the desired letter is over the printing point. Connected with the receiver are a large number of relays, various combinations of which operate a few magnets for printing the characters. Four messages may be sent at one time in each direction over the same wire, making a total of eight messages, and at a speed, it is claimed, of forty-five words per minute. This remarkable machine is not yet ready for the market, requiring considerable simplifying before it can come into general use.

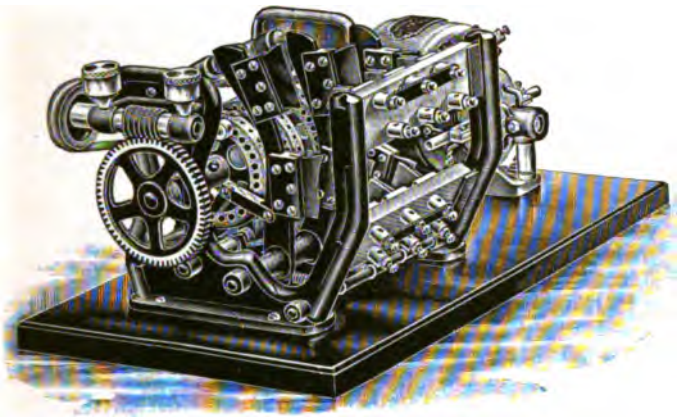
The printing telegraph of Donald Murray is intended for long-distance work, and is in use by the Postal Telegraph Company. In this interesting and simple machine, an endless tape, punched with

holes of a modified Morse code, is translated mechanically to a typewriter and written out, the attendant simply turning a crank at the side of the typewriter, which operates at about three times the speed it could be fingered. In the illustration the typewriter is removed to show the interlocking mechanism *H*, by which the perforated characters on the tape are made to strike the keys of the Roman alphabet on the typewriter. The turning of the crank on the right draws the tape along and introduces a series of little feelers to the holes in the tape. As these feelers drop in they occupy a position that allows the proper type-bar of the typewriter to drop and print a letter. A slight electric current furnishes power for depressing the keys. It is apparent that this system is exceedingly well adapted to taking long reports for the Associated Press, or anything that is lengthy. By using carbons in the typewriter several copies may be obtained at the same time, and each will read exactly as does the punched paper tape.

A recently exploited novelty in telegraphs is a system for using slight electrical shocks sent in the Morse code, to be read by the finger-tips, just as any operator might now read a message if his finger took the place of a key in receiving the "tick, tick" of the ordinary telegraph receiver. It was originally designed for the use of deaf mutes and blind mutes, but it is apparent that it might be applied to many other uses. Two persons can walk along the street with instruments in their pockets and carry on a conversation that would be entirely unsuspected by any onlooker. In the same way at night, from different rooms, with a connecting wire, they could talk without being overheard or disturbing any one else, or even getting out of bed. The sensation is received by means of thimbles made like open-end sewing thimbles and placed one on the thumb and one on the forefinger. To send a message one person brings his finger and thumb together, making the dots and dashes of the Morse code, and the other person reads the message by feeling, without any effort. The thing is so simple and requires so little apparatus, that it should find considerable use. A very slight battery and connecting wires are all the mechanism needed. Any one having an electric door-bell in the house can steal a little of the current, and rig up the apparatus for use as wanted.

Electric signs have attained a high state of development, and in every large city may now be seen nightly signs that are changed in the reading every moment by electrical mechanism. One of the machines for accomplishing this result is the electric light and sign flasher here illustrated. This can be used to operate a variety of

signs, as the waving flag, rotating wheels, etc., these being electric optical delusions operated automatically. In one form of machine a man with a typewriter is in control, and the sign displays whatever he writes on the machine, up to the limit of the number of words it carries.



Courtesy Electric Motor and Equipment Company.

Electric Sign Flasher.

Electricity is undoubtedly gaining ground in therapeutics. While the physician no longer attempts to cure patients of all sorts of ills by having them take a current from a battery, it has come to be recognized that certain things can be accomplished. The value of the electric cautery was demonstrated many years ago, and there is a long list of instruments in which the electric light coupled with a speculum enables the physician actually to see the condition of interior membranes in his patients. The circulation in a particular part of the body can be stimulated by the electric current, and the heart's action can be affected. Electrical anæsthesia has also been applied superficially for dental operations, and a French surgeon has succeeded in producing insensibility to pain in a patient during a very trying operation by subjecting him to the action of currents of high frequency during the whole course of the operation.

A French physicist, M. Leduc, produces local anæsthesia and also sleep by a continuous current from an accumulator, placing a small resistance in the circuit. If this current is applied to the wrist, there is a prickling sensation, but no feeling otherwise. If applied to the head and the buttocks, respiration is at first stopped, and on reducing the current the breathing is resumed, the patient remaining asleep with what appears a natural and tranquil repose. As insomnia

is a result of disturbance of the nerve-centres, it is reasonable to conclude that this method of quieting the nerves may prove to be the practical cure for this trying affliction. The drawback to the introduction of the system lies in the fact that when the current is first applied the immediate result is to produce apparent death, from which the patient has to be resuscitated. Physicians will want to feel very sure of their ability to bring patients back to a normal condition on short notice before they will adopt this method of treating insomnia.

In this connection it is well to note the latest form of X-ray apparatus and of fluoroscope. These are well shown in the accompanying illustration.

Electric heating has made considerable progress because of its convenience, though it is vastly more expensive than heating with coal. Still, when the coal gives out, the human race may be very glad that it has in every waterfall a power that may be transformed into electricity and thus into heat. Electric cooking is not so expensive in a small household, where its use is intermittent, and the few cents of extra cost are offset in hot weather by the fact that very little heat is sent out into the room. As a plate-warmer, or convenience for supplying a little hot water when wanted, or heating a hair-curler at a lady's dressing-table, the electric heater is in some demand. In laundries it also has some sale, as it saves times and can be turned off to stop expense when not in use. A theatre can be heated electrically with a heater under every chair in a manner agreeable to the patrons, as the heat comes where wanted, and can be shut off by the occupant of the chair if he or she is too warm.

The *Electrical Review* estimated in October, 1902, that there were at least 150,000 electric car-heaters in use, 50,000 heating-irons, and 5000 chafing-dishes. The United States census gives the sales during 1900 of electric heating and cooking apparatus, including the rheostats, at $1,186,000, and it is safe to say that it is now (1904) at least a million and a half a year. A single New Jersey hat-factory uses 250 horse-power for electric heating apparatus, which is found specially useful in that business. Whenever the power-furnishing companies choose to make a specialty of selling current for this purpose at a price that consumers can afford to pay, the use will increase very rapidly. That they have not done so is perhaps owing to the fact that the trolley companies have had such rapidly increasing demands from traffic that they cared not to go into another field, while the electric-light plants are too often controlled by gas corporations that prefer to sell gas for heating.

The X-Ray and Fluoroscope in Surgery.

I, Induction coil; P, primary current; S, secondary current; C, Crookes tube set at correct angle; F, Edison's fluoroscope; X, point in the tube from which the hemisphere of X-ray activity radiates.

The principle of an electric heater is simply the use of a metal offering sufficient resistance to a current of electricity to be readily heated when a current is turned through it. This metal is surrounded by some non-inflammable conductor of heat, as porcelain or asbestos. In a well-known type a metallic paint is fired upon mica strips, which are formed into groups or sets, so that a heater can be built of any size by adding more sets. For heating an electric car either four or six sets of conducting wires coiled around porcelain tubes are commonly used, the current being taken along with the motor-current from the trolley wire or other source, which is unfortunate for the passengers at times, for when the power is short the heat is ruthlessly shut off. The average cost of heating electric cars by electricity is perhaps seventy-five cents per day of eighteen hours, and the temperature of a car may be raised in this manner about 40° F. above that prevailing outside, in spite of the constantly open doors.

Early in 1902 there was a public exhibition in Milwaukee of an invention for using the electric arc for cutting steel. An enormous boiler foundation, made in one piece of metal, had to be removed from the basement of a building, where it had been put at the time the basement was built. It was so heavy that local mechanics despaired of being able to cut it in order to get it out. The inventor of the process of using the arc for steel-cutting was called in, put on a pair of blue spectacles, connected his apparatus with a strong current, and touched the steel plate with his carbon point. A strong white light and brilliant flame sprang up, and the steel was cut, or more correctly burned, away, at the rate of a foot in five minutes, so that within a short time the whole plate was divided into blocks that could be transported away. Whether the invention will find many practical uses remains an open question. So far it has served principally to alarm bankers as to the efficiency of their great safes if attacked by an up-to-date electrician.

Electric track-welding has become an important business, and the methods employed have shown much improvement within recent years. Rail-joints are welded together just as they lie on the ties, a welding-train of two cars doing the work. The result is a practically continuous rail that makes riding less jolty for passengers and also prevents the ends of rails from wearing out by the pounding of the car-wheels, as is the case where the joints are slightly open. An improved process of doing the work was introduced in 1897 and another in 1901. The latest outfit is mounted on trolley-cars of special design having axles that may be adapted to different

widths of track. The first operation is sand-blasting, to free the rail-ends from dust and dirt. An apparatus that resembles an enormous horseshoe is projected from in front of the forward trolley-car, being suspended by a crane. This is the welder, and its ends are placed on either side of the rail at the joint. Thin strips of steel having been placed at the sides of the joint, the current is turned on, and the metal at the joint soon rises to a welding heat. Then the current is shut off, and the hydraulic jaws produce a great pressure, as much as thirty-seven tons, on the joint. This completes the weld very quickly. The current used approximates from

Electric Track-Welding Machine.

25,000 to 30,000 amperes at seven volts. The supply at the welder is regulated at about 300 volts. After welding, a grinding device is employed, in order to reduce the slight bulge which is produced purposely. This grinding is done with an emery-wheel under the guidance of a man on the car. With this apparatus a line of track is welded in a comparatively short time at moderate expense.

Electric trains are now run that emulate the European trains de luxe, as they call a string of Pullmans. One of these elegantly furnished electric parlor-cars is shown on p. 36, being arranged for summer travel. Within a few years it is probable that the more

prominent lines of electric cars running to seaside resorts will run these parlor-cars occasionally, charging a higher rate of fare, thus enabling those who have the spare cash to ride in comfort and escape the crowd.

Although the electro-magnet is one of the commonest parts of electrical machinery, yet the magnet for holding or lifting purposes has been employed but little. There is first the toy magnet which is used for drawing pieces of steel out of the eye. Then the magnetic

Courtesy Electrical World and Engineer.

Electro-Magnet for Lifting Pig-Iron.

clutch, for holding a piece of work to the bed of a machinist's drill or planer, and Edison's large electro-magnets for separating the iron from crushed ore. There are also little magnets that pick up the tacks or brads for the machines that make gift-boxes for berries, and tremendous electro-magnets in steel works, that are attached to cranes, and that will pick up ten- or twelve-ton pieces of metal, by magnetism alone, to transport them to some other point, saving the time that would be lost in fastening them with hooks and chains and releasing them again.

It is well known that a great deal of electrical work is done with the alternating current and other work with the direct current, and that it is often necessary for electricians to convert one sort of current into the other for some specific use. For this purpose a converter is employed, being a rather massive machine, one rated at eight kilowatts weighing about 750 pounds. Early in 1903 Peter C. Hewitt announced that he had succeeded in making a very sim-

Courtesy Literary Digest.

A Selective Converter.

ple "selective converter," and that one of four pounds' weight would do the work of the 750-pound converter. His device is a globe that somewhat resembles a Crookes tube, as used in X-ray apparatus. He fills the glass globe with mercury vapor of a certain degree of attenuation, and admits the terminal wires of the various currents into the globe. The theory of its operation is that, "when an alternating current is caused to jump through a space filled with mercury vapor of a certain degree of attenuation, it presents a ready

passage to certain portions of the wave, whereas other portions of the wave are damped back, or form a selective electric valve, which allows impressed electromotive force of a certain character only to flow through the apparatus."

This remarkable invention cuts away the barrier separating the alternating and direct-current fields, and constitutes one of the most important mechanical improvements in electric apparatus of the opening years of the century.

A Russian engineer, Nicholas Gherassimoff, has invented a novel electrical means of protecting vessels at sea from collisions with

Electric Parlor-Car Interior.

other vessels or with derelicts or with shoals. His idea is to provide electrically propelled bodies, which he calls feelers, moving in advance of the vessel at the same rate of speed, and far enough under water to protect the hull of the ship. He provides three feelers, one in line with the keel and the others at some distance to the right and left. The feelers are controlled by three electric cables, which have a junction point connected with an indicating apparatus on the vessel. This indicator shows when a feeler is thrown out of its natural course, which is a sign of danger. There are also little light-buoys sailing over each of the feelers, so that under

favorable conditions it can be seen whether they are performing their work in proper position.

The telegraphone is a much-advertised electrical instrument that has so far failed of commercial success, though it does seem as if it ought to be very valuable. It was invented a few years ago by a Dane named Poulson, and was exhibited at Paris in 1900. It is a magnetic phonograph, and has a long hardened steel wire that is passed quickly near the magnet of a telephone receiver, with wonderful results. The wire appears to acquire in the form of permanent magnetism all the vibrations that occurred in the receiver at the time it was exposed, and when the wire is passed under certain small bits of iron attached to a diaphragm, the sounds from the telephone are reproduced, just as they would be in a phonograph, with the improvement that they are rid of that scratching noise which is so trying to the ears of most people.

Electric haulage in canals, though abandoned after an imperfect trial on the Erie Canal, is a success in Belgium. It doubles the speed of haulage without increasing the cost. Electric automobiles are used to draw the canal boats, just as did the mules before them. These autos are only about five horse-power, and cost little. When two of them meet on the tow-path, they swap boats. Where the canals are deep enough an electric tug is run, drawing its power from an overhead wire by a trolley-pole. These make a speed of about eight miles an hour with their tows.

The Miami and Erie Canal Transportation Company has a thirty-five-year franchise to operate an electric towing system between Cincinnati and Toledo, a distance of 244 miles. At present forty-two miles are in operation. The company owns seven Westinghouse-Baldwin electric locomotives of the mining type and twenty boats with a capacity of sixty-five tons each. The track is standard gauge, and one locomotive can tow six boats at a time at a rate of four miles per hour, this being the maximum allowable speed on account of excessive wash on the canal banks.

Power is transmitted from Cincinnati by three-phase, sixty-cycle, 4200-volt, alternating current to a sub-station five miles out of the city. Here, by means of transformers and a synchronous motor-generator set, it is transformed to 33,000 volts and twenty-five cycles and transmitted to other sub-stations twelve miles apart along the line, where the voltage is reduced to 1170 and at this pressure fed to the trolley-wires. The high-pressure transmission cables are of aluminum, but the trolley-wires, two in number, are copper. The locomotives are equipped with two eighty horse-power,

three-phase induction motors, the first of this kind to be used for traction purposes in this country.

But this chapter grows too long. The writer recognizes that this is but a very cursory and superficial summing up of the advances made in recent years in electrical science and industry. The subject is large enough for ten volumes instead of one short chapter, and it has been thought best to describe some of the most interesting points rather than to attempt a dry catalogue of all the improvements undertaken and discoveries made. No industry stands still, and least of all the electric industry, which is yet in its infancy, and is dividing into numerous industries, with the promise in time of invading a large number of fields as yet untouched by its magic influence. Verily, this is the age of electricity.

ELECTRICITY FOR THE MILLION

SOME one has said that " electricity makes the world go round," and, while this may not be literally true, in a figurative sense the facts go far to back up the assertion. The progress made in a dozen years in electrical industries is really marvellous, while the magic force has intruded itself so insidiously into our daily lives that we are apt not to appreciate how completely it has imbued almost everything we touch and do.

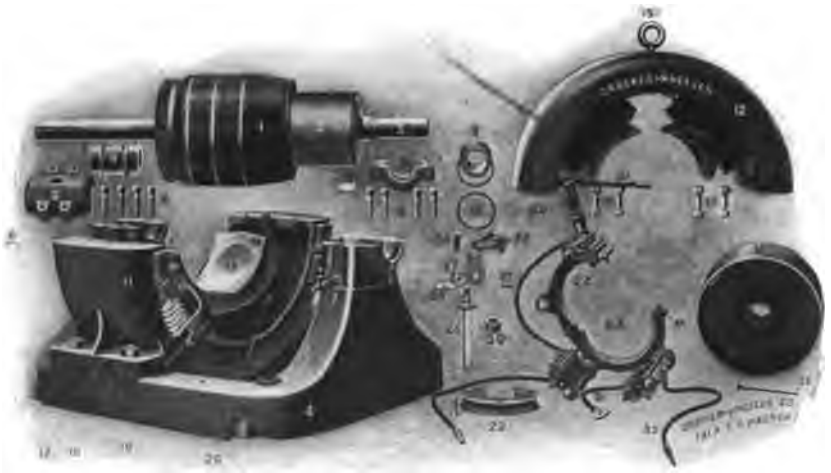
In this chapter let us consider electricity as it enters into and surrounds us in our daily lives. I use the word electricity here in the broad sense of all things that depend upon or utilize this potent agent. A few statistics will assist us at the outset. In 1900 there were 580 establishments in the country manufacturing electrical apparatus and supplies, and 712 more that were partially engaged in this business, the number being three times as great as in 1890. In this year of 1904 the number has probably gained fifty to sixty per cent., so that it is within bounds to assert that there are nearly 2000 establishments in the United States more or less devoted to the manufacture of these supplies. The product of these establishments, estimated in the same way, amounts to $150,000,000 a year. When it is understood that these figures are exclusive of the telegraph, telephone, electric-railway, and electric-lighting industries, which are treated of in other chapters, it is very apparent that something is doing in the smaller fields of electrical industry.

In the census year of 1900 over $10,500,000 worth of dynamo-electric generators were in use in the United States, furnishing a total horse-power of 770,000. To this figure we must add $24,000,000 worth of electric motors, of which $14,000,000 were for direct current and $10,000,000 for alternating current, a large proportion of the above being used for automobiles, fans, elevators, etc.

Just here the non-technical reader may wish to gain a clearer idea of the construction of a dynamo and a motor. The dynamo is a mechanically-driven machine, for which a water-wheel or more commonly a steam-engine furnishes the power. It has an armature (1), or core of iron wound with copper wires, and when this armature is rotated by a steam-engine close to the poles of an electro-magnet a current is set up. By fixing on the same axle or shaft (3) as the armature a commutator (2), or device for rectifying the

current, and allowing copper brushes to rest lightly on this rotating commutator, and connecting wires with the brushes, a direct current may be led off, and the greater part of the energy received from the steam-engine may be delivered to a motor at a distant point, or to a light-circuit, or to heating apparatus, or applied to any purpose for which the current is useful. An electric motor is simply a dynamo reversed in action. The current, coming in on two wires to the commutator, causes the rotation of the armature, and this drives a pulley, from which the power may be taken by a blet.

Such are roughly the general principles of a dynamo and motor, omitting the detail. In practice, dynamos are differentiated



The Parts of a Dynamo.

from motors, and a great many details of construction are introduced to secure certain results. If the electro-magnet, or field-magnet, as it is more commonly called in this usage, has only two poles, the machine is said to be bipolar; if more than two, it is multipolar. Whether or not the machine has a commutator determines whether it shall send out a direct or an alternating current, the latter being a current which is turned in one direction and then in the opposite, alternating commonly at the rate of 7200 times a minute, while the direct current flows always in one direction.

A simple alternating current does very well for transmission purposes and for electric lights, but for motors, except in very small sizes, a polyphase current must be used. An alternating current

generator can be so constructed that it will generate two or more currents alternating at the same rate, but not at the same time. That is, one current will just be stopping and changing its direction when the other current is flowing with full force; the next instant of time the first current will come up to its full value and the second current will stop and reverse. Two or three currents alternating in this way can be combined and transmitted to a distance on three wires and the combination is called a two-, three-, or in general a polyphase current. When such a polyphase current is applied to an alternating current motor, called an induction motor, it produces a uniform rotation of the armature, much in the same way that in a marine engine a uniform rotation of the shaft is produced by having the cranks connected at right angles to each other, or 120 degrees apart in case there are three cranks.

In the case of the motor, one current is doing its maximum work while the other is going through the zero point, exactly as in the engine, one crank is doing its maximum work while the other is at its dead-centre and doing nothing. An induction motor operated on a single-phase current will run after once being started, but, like a single-crank engine on dead-centre, will not start of itself.

Only twelve per cent. of the dynamos made are alternating-current, but the size and power of the alternating-current dynamos are so much greater on the average that forty-five per cent. of the total horse-power of dynamos built in the census year were of this type. A peculiarity of the alternating current is that, by the use of transformers for raising and lowering its pressure, it can be delivered at very considerable distances at slight loss, whereas the direct current is limited in quantity, pressure, and distance.

The alternating-current dynamo tends to grow larger and larger. Thomas C. Martin, expert special agent of the Census Bureau, calculated that the average dynamos of this sort manufactured in 1900 were of 254 horse-power, but he states that they are growing so fast that this really appears a minimum figure. Thousand horse-power dynamos are becoming common, and even the great 5000 horse-power dynamos at Niagara Falls have become too small for their needs, and the latest dynamos going in there are of 10,000 horse-power. In these machines the current is generated at a potential of 12,000 volts, which dispenses with transformers for raising the voltage. The cost of building these enormous dynamos is seven dollars per horse-power, which is about half the cost of building the average dynamo.

Curiously enough, the development of the dynamo seems to

have affected the business methods as well as the mechanical lines along which electric lighting and power have developed. The first companies in the electric field were those that took a comparatively

Cutting Wheel-Pit for Shafts of the Great Dynamos at Niagara Falls.

small territory and undertook to introduce arc lighting, incandescent lighting, or a trolley railway, each enterprise, as a rule, being separate. The two kinds of light were first rivals, then they tended to grow together, and now there is a tendency for companies to furnish

both electric light and power to customers for any use, this sometimes including power for operating a street railway.

The fact that the alternating current could be sent to greater distances than the direct, led to expansion of territory by the users of alternating-current dynamos, until practically all companies have settled down to the same general basis of operations, generating current with alternators of the polyphase type at large central stations, and transmitting it at high-pressure to sub-stations, where it can be sent out under lower pressure as either direct or alternating current or used to charge batteries for storage. This method has proved best for railways, for lighting, and for general power purposes, and business conditions are adjusting themselves to it. Direct-current dynamos are not increasing rapidly in use, and are employed

A Three-Unit Balancing Transformer.

mainly in isolated plants, where there is not likely to be any demand for serving current to others.

It is apparent from the foregoing that the transformer plays an important part in modern electrical equipment. The transformer is a sort of modern form of the induction coil, with which students of electricity were familiar twenty years ago. Its essential parts are a core of laminated sheet-iron wound with two coils of copper wire, one coil consisting of a great many turns of fine wire, and the other of a few turns of coarse wire. If the fine wire coil is connected to the line a current at a much lower pressure can be drawn from the other coil, or secondary, as it is called. If the connections are reversed and the fine wire coil used for the secondary, a current at a greatly increased pressure is generated. Thus the transformer can

be used either to "step up" or "step down" the pressure, and the ratio of transformation depends upon the ratio of the number of turns in the two coils. If, for instance, we have a 1100-volt current we wish to use for incandescent lamps at 110 volts, we simply use a transformer having a primary coil of 500 turns and a secondary coil of fifty turns.

In 1890 transformers were able to furnish current to only a few lights, because of their small capacity. Then their average capacity was from eighteen to twenty amperes, or sufficient for perhaps forty lights; now they average about twelve horse-power, with a capacity of perhaps one hundred and fifty lights. Some of the largest transformers in the world are those installed at the Niagara power plant, these being 3000 horse-power each.

The electric motor is not so new a thing as many believe. It was used for propelling boats and cars in 1830, receiving current from a battery. But, as the primary batteries of that day were expensive and non-commercial, there was really no use for a motor. It was the discovery of the fact that a reversed motor became a dynamo, and the perfecting of the dynamo, that made the present system of power transmission by electricity practical. Very satisfactory electric motors were shown at the Philadelphia electrical exhibition in 1884, but they made such slow progress that in 1890 there were in use in New York City only 360 small motors, of a total of 310 horse-power, and only 4.4 per cent. of the manufacturing power used in the country was electrical. After 1890 the demand for motors came with a rush, and the census returns for 1900 show that their use increased 1897 per cent. in the decade. The census records the railways as using in 1900 motors to the amount of 666,669 horse-power, automobiles 8220, fans 12,766, and elevators 6730. The longest distance to which power is transmitted to drive motors is 220 miles, from the Sierras to San Francisco.

One of the most important and widely used of all electrical devices is the battery. There are two kinds of electric battery, the primary and the secondary or storage battery. The former, which we see used for telephones, electric bells, annunciators, gas engine igniters for automobiles, and countless other things which require only a small amount of power, consists usually of two plates, one of zinc and the other of carbon, immersed in a solution of sal-ammoniac, the whole being contained in a jar. For the sake of convenience and portability, the solution is commonly mixed with plaster of Paris, making a pasty mass; the whole cell is sealed air-tight, and we have the ordinary dry battery.

For furnishing large quantities of electric power primary batteries are inadequate; so in electric-light or railway-power stations storage batteries are used. The first storage battery of importance was the Planté, made in 1860, and having lead plates immersed in a ten per cent. solution of sulphuric acid. Faure improved the storage battery greatly about 1880, and it has steadily developed ever since. In batteries of the Faure type the plates are first covered with a paste of litharge or lead oxide, and then a strong current of electricity is sent through the cell. The current decomposes the oxide on one plate, leaving a coating of porous spongy metallic lead, while on the other plate the oxide is converted into lead peroxide. When the battery is in this condition, it is said to be charged, and is capable of furnishing an amount of electrical energy nearly equivalent to that which was first required to charge it. Thus we see that electricity is not stored up in a storage battery, as is commonly supposed, but the electrical energy is converted into chemical energy, and in this form can be stored indefinitely.

The storage battery recently developed by Thomas A. Edison has for its elements nickel-oxide and iron immersed in a solution of caustic potash. This battery promises great things for automobile use, on account of its light weight and great durability, but for central stations the lead storage battery will probably hold its own for some time to come. Storage batteries are used chiefly in power stations where the load is variable, the reason for this being that at certain hours, usually between 5 and 7 P.M., the station is called upon to furnish an amount of power far in excess of the average load. In the early morning hours, when the load is light, some of the dynamos are used to charge the battery; then, when the heavy load comes on and the station is taxed to the limit of its capacity, the storage battery is used to help the dynamos and returns the energy which was stored up in it.

When the central distributing station receives its power from a distance as is usually the case when water-power is employed, alternating currents are used for transmission purposes. An alternating current cannot be used for charging a battery; so the high potential alternating current is stepped down by means of transformers, and then converted into direct current by means of rotary converters, the rotary converter being an alternating-current motor and a direct-current generator combined in one machine. The direct current from the converter is used to charge the battery, and when the central station supplies power for street cars, which always run on direct current, both the battery and the converters supply the current. In

case extra power is needed on the alternating-current distributing lines, the battery current is changed back into alternating current by means of the same converter and used in its original form.

At the extremity of a long suburban trolley line the electromotive force or pressure is liable to be low, on account of "drop" in the line. To overcome this "boosters" are sometimes used. A booster is a machine resembling in outward appearance a direct-current motor or dynamo, it being in reality a combination of both. It receives the low-pressure current from the line and in return supplies a high-pressure current to the line, in this way keeping the pressure up to 550 volts when it otherwise would be down to 300 volts or less. Sometimes a storage battery is used in connection with the booster. When few cars are running the booster charges the battery, but when the load is heavy and the pressure is low the current from the battery runs back into the line. A system of this kind regulates itself automatically; the batteries are always charged and are said to be "floating" on the line.

During the ten years ending with the census year, the railways of the United States installed about 2,000,000 horse-power of motors on cars and about 1,000,000 horse-power of dynamos to drive them. The census experts estimated the investment in storage batteries in the United States in 1900 to be $11,000,000, with a capacity of 300,000 horse-power hours.

The copper industry depends very largely upon electric apparatus for its support. Most of the commercial copper is produced electrolytically, and thus electricity both gives to and takes from the copper industry. Copper is beginning to have a competitor in aluminum, however, as a conductor. An aluminum wire of the same current-carrying capacity as a copper wire is one-fourth larger in diameter, but weighs only about one-half as much and costs less. So copper must have a care, or the light metal will be ousting it from its best field.

The insulated wire and cable business of the country amounted to over $21,000,000 in value in 1900, this large business having grown up entirely as tributary to electrical apparatus. The first braiding of insulation on wires was done by F. Bridges and C. S. Bishop, about 1859, using the methods then common to braiding whips. A number of efforts were made to introduce rubber into the insulation, these being finally successful, when Mr. Bishop laid a cable across the Hudson at New York City, it being protected with three gutta-percha coverings. From this sprang the use of submarine cables for crossing rivers, and the use of similar cables in underground conduits in cities, etc., is an outgrowth.

The tendency to place electric wires underground is a growing one. At first this was considered a hardship by the companies having to bear the expense, and it was only forced by legislation against networks of overhead wires. But as methods of underground insulation improved and cables were laid on a larger scale, it was found to be less expensive than at first, and that this expense was largely offset by a reduced charge for repairs and an improved service to the public, so that now the practice is often undertaken voluntarily by companies having numerous lines to care for.

Overhead telegraph and telephone wires are often thrown out of business during severe storms, entailing a loss of receipts as well as extra expense for repairs on the companies, whereas the underground wires are not only free from this sort of annoyance, but require very much less in the way of general repairs. When once put under ground in a right manner, the wires are apt to stay right. The method of laying wires underground consists in wrapping each individual wire in an insulating sheath, as of specially desiccated paper. Bundles of these insulated wires, forming a cable, are then enclosed in a leaden pipe, the work being done in a dry atmosphere to avoid all moisture. The bundles of wire enclosed in the lead pipe are reeled on enormous wooden drums, so that considerable lengths can be handled conveniently.

A trench being dug and vitrified tile conduit laid in, the lead cable is run into the conduit, being first well greased with petrolatum, which not only serves to lubricate its passage, but is a farther preventive of moisture. The trench is made deep enough to avoid contact with anything from the surface that might be deleterious, and the sections of conduit are carefully joined with cement. At points where sections of cable have to be joined together extra care is taken to secure the same conditions of dryness and perfect insulation. The wires and the insulating paper are all spliced at different points, so that there is little bulging of the cable, and the junction of the adjacent lead pipes is carefully sealed.

The British Postal Telegraph Department in 1900 placed under ground all its wires between London and Birmingham, a distance of 117 miles, for the purpose of rendering its service more positive and unfailing. The larger portion of the line was already under ground, the work consisting in changing those sections that were operated overhead. This is, or was at that date, the longest underground telegraph line in the world.

The American Bell Telephone Company now has more wire under ground than above, they having a little more than a million

miles of wire in use. Of those above ground a large portion are now encased in insulated cables, very much after the underground method. In long lines, test-boxes are placed at intervals of a few miles, at which points access may be had to the wires to test their making the proper connections, and an opportunity is afforded to connect branch wires. All electric-lighting circuits in large cities are now laid under ground, and the same is true of many small cities.

Among the minor developments of electrical industry may be mentioned annunciators or call-bells, of which a quarter of a million dollars' worth are made in the United States yearly; electric clocks, automatically corrected or kept to the true time by a current sent over a wire from a central source, which industry does a business of $150,000 a year; lightning arresters and fuses, manufactured to an annual total of over $600,000; and electric meters, which total up about $2,000,000 yearly.

There are several forms of lightning arrester on the market, all operating upon the same general principle. It was discovered by A. J. Wurtz that a high-potential, high-frequency, lightning discharge will jump across an air-gap and find its way to the ground in preference to following a circuitous wire into a power station or trolley-car and there doing damage. The usual form consists of a series of cylinders made of an alloy that will not arc, and with a knurled surface, these being set about a thirty-second of an inch apart on a porcelain block. The spaces are for spark gaps, and when a bolt of lightning enters, it jumps the gaps and is led into the ground; the arc which follows is interrupted by the non-conducting oxide thrown off. This is used generally in connection with a flat spiral choking coil, which impedes the lightning but interferes very little with the working current.

A very high-potential lightning arrester usually has ten, twenty, or more cylinders arranged in series, with a non-inductive resistance of from a hundred to several thousand ohms connected in parallel with one-half the gaps. It is used with choking coils, and the number of spark gaps depends upon the potential of the circuit. The Thomson magnetic blow-out consists of a pair of curved metal strips between the poles of a compact electro-magnet that is energized by the arcing current. The line being connected with one curved strip and the ground with the other, when the lightning comes and leaps the gap, the arc is repelled to the tips of the curved strips and blown out.

How impossible it is even to mention the great variety of electrical supplies now on the market can be gathered from the fact

that the catalogue of a well-known supply house enumerates over two thousand separate and distinct articles, apart from large electrical machinery, and classed as supplies. These include such things as physicians' batteries and other electrotherapeutical apparatus, scientific apparatus for colleges, electrical toys, cigar- and gas-lighters, insulators, brushes, carbons, special tools for burning patterns on wood or trimming the pile of velvet, etc., etc.

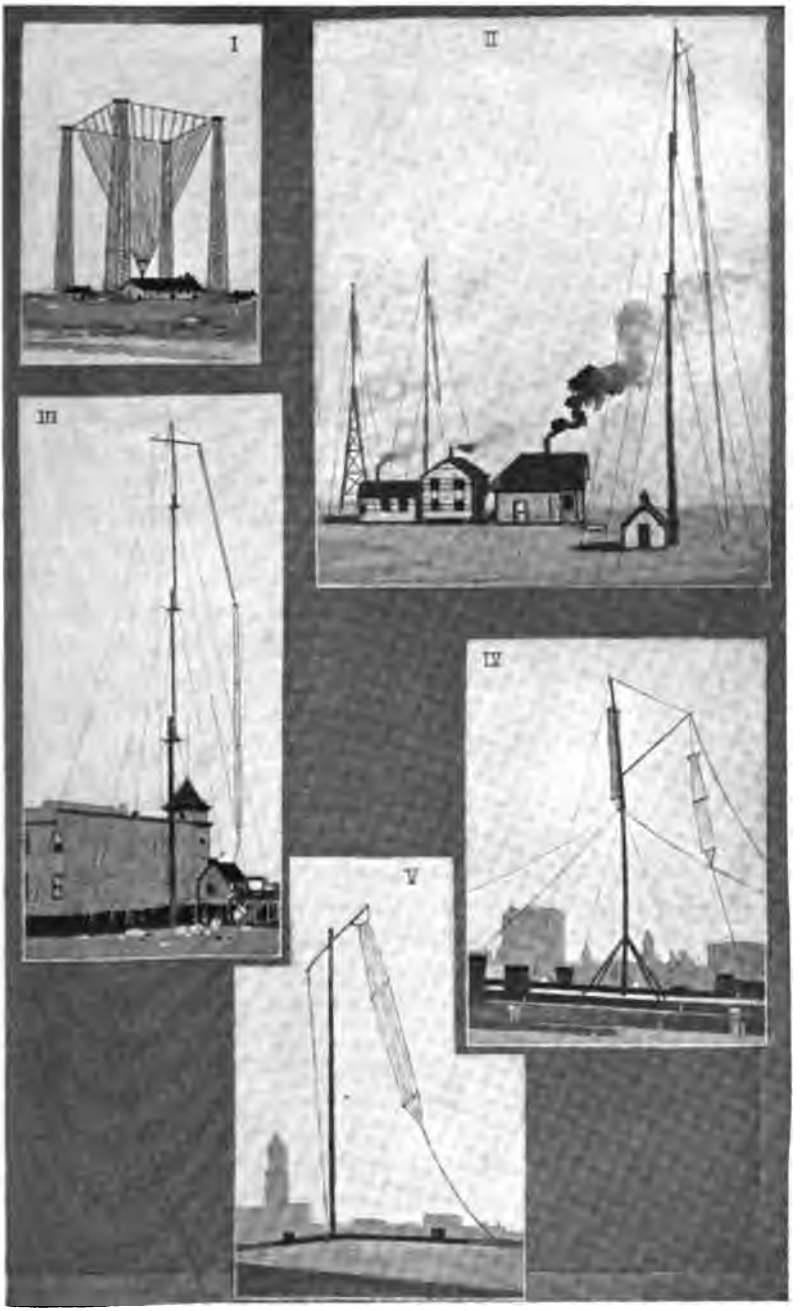
I am obliged to leave the subject here, as too large for farther space in a work of this character. The reader who is specially interested in electrical development will find plenty of books in any public library, and for recent and up-to-date information there are a number of reliable and well-edited electrical journals.

MARCONI'S VICTORY OVER THE ETHER

THE ancients pictured Jove as playing with the lightning; now Man harnesses the electric current that it may do his work. When Benjamin Franklin took a shock from a kite-string, when Cyrus W. Field tried to girdle the earth with a cable, when Thomas A. Edison burned a platinum wire in a vacuum, when Alexander Graham Bell first heard a whisper over the telephone, when the letter S came out of the mists of the Atlantic to Marconi's coherer—then mile-stones were planted along the highway of electrical progress. And as the years go on and we rush forward with increasing energy, it seems as if these mile-stones thickened by the way, and, while they used to be separated by years, now only months or sometimes weeks intervene between the announcement of one startling success in the world of electricity and the next new marvel.

The more men study this wonderful thing we call electricity the more it seems to give forth that which is useful and convenient for mankind. Because we cannot handle it as we can iron and wood, and because it does not so readily manifest its presence to the senses, its properties remained hidden from primitive man. What we know of it now is mainly through studying its effects and reasoning from result to cause. We can see it in the lightning, the arc lamp, and the incandescent light; we can feel it in the current of the physician's battery, and note its pulling power in the magnet; we know that it may both kill and cure—and for the rest the average man or woman depends upon the electrician or the scientist, and takes his word as to phenomena whose description is too full of technique to be agreeable.

That we may describe intelligibly the more recent developments in this field, let us first try to arrive at an understanding of the nature of electricity. It manifests itself in a hypothetical medium named the ether. This ether is assumed to pervade all things. When the ether is disturbed, vibrations are set up. Some of these vibrations come to our senses as light, and some of them we know as electricity. When the disturbance is sufficiently violent, we have heat as a manifestation. It is not strange, then, that by electricity we can produce light and heat; neither is it strange that we can act upon things at a distance, since the medium is all-pervading. Through electricity it is theoretically possible to repeat almost any mechanical operation at a distance.



Marconi Wireless Telegraph Stations.

I. Four-Tower Station (see page 55); II. U. S. Wireless Telegraph Station at North Tru; III. Wireless Telegraph Tower, 210 feet high; IV. Mast on Michigan Avenue; V. T-Station.

Electricity, like water, seeks its level, and, as water goes down through every convenient aperture, so electricity flows along the lines of least resistance. We can charge a substance with electricity by friction, provided that substance is insulated,—that is, surrounded by poor conductors of electricity. By burning coal under a steam-boiler, and using the pressure of the steam to drive an engine, and using the force of the engine to rotate an arrangement of wires constituting an electrical magnet, we can transform a part of the energy of the coal into a current that flows out along conductors and will drive motors to do our work. From one of the same conductors we can take off light, either by leaving a short gap in the conductor, across which the current leaps, forming an electric arc; or by using a filament that is a poor conductor, as carbon, and which therefore heats with the stress and becomes incandescent. Heat for any ordinary purpose may also be obtained by the use of poor conductors or resistance in the circuit.

For fifty years the student in electrical science has operated by means of wires, choosing good conductors, as copper, to convey currents, and transmit thought, energy, light, motion, etc., to some desired point. Now comes Marconi, in the train of other exploiters in the wireless field, and demonstrates that if only sender and receiver are tuned alike, and the instruments delicate enough. we can use the ether around us to carry our messages. This is done by means of the etheric waves whose existence was demonstrated by Heinrich Hertz, and which are therefore called Hertzian waves. These waves or vibrations of the ether are much slower in rate of vibration than light waves, and Marconi and other inventors who have made progress in wireless telegraphy have done so by devising means for better controlling and detecting these waves. Previous to December, 1901, two hundred miles was the greatest distance to which any message had been received without wires.

This record was held by William Marconi, who was even then the acknowledged leader in this line of scientific research. In that month Marconi left his station at Poldhu, Cornwall, and sailed for Newfoundland. He left instructions that after the time for his arrival in America, the letter S should be signalled from Poldhu from 3 to 6 P.M. daily, this time corresponding to 11.30 to 2.30 at Signal Hill, St. John's harbor, the place at which he had established his receiving station. None but his confidential assistants knew his purpose. He had calculated that, with a certain amount of electrical energy sent out at Poldhu, the waves should be strong enough to affect a coherer at St. John's, 1800 miles distant; but he could not afford to let the world know if he failed.

To receive the Hertzian waves an elevated wire was required. He first tried sending one up in a balloon, but the strong winds which prevail there carried it away. Then he tried kites, and on the memorable 12th of December, 1901, succeeded in keeping his kite elevated over four hundred feet for a period of four hours, during that time hearing the letter S recorded on the Morse instrument, by three taps, at least twenty-five times. Notwithstanding that he knew better than any one else that the expected result should come, we can imagine the feeling of reverential awe that must have swept over Marconi as he realized that he was hearing for the first time sounds actually sent out by his own direction from the other side of the broad Atlantic. Even the great Edison doubted the truth of the reports when he heard them, for at that time it was generally thought that the Hertzian waves travelled in straight lines, though Marconi had proved to his own satisfaction that they followed the curvature of the earth.

Almost the first recognition that Marconi received came in the shape of a warning from the Anglo-American Cable Company that he was interfering with a franchise of theirs in telegraphing from St. John's. So he chose Table Head, a promontory east of Glace Bay, Cape Breton Island, for farther experiment, and began the erection of a station there, and later one at South Wellfleet, Cape Cod.

But he was not long in breaking another record. On February 25 and 26, 1902, on board the steamship Philadelphia, steaming towards America, he received messages from Poldhu up to 1551.5 miles and signals up to 2099 miles. Curiously enough he found that messages sent during the hours of daylight at distances of over 700 miles failed entirely, whereas at night he was able to receive them to more than double the distance, proving apparently that daylight exerted an unfavorable influence on the Hertzian waves. By improving his apparatus he was able to secure better results, however, and during the following summer received messages in the harbor of Cronstadt, Russia, from Poldhu, 1400 miles distant, this being accomplished in the presence of the Czar and the King of Italy. Victor Emmanuel was so impressed that he gave Marconi the use of the cruiser Carlo Alberta for six months, to assist his experiments.

January 18, 1903, Marconi sent from Cape Cod a message dictated by President Roosevelt to King Edward, which was successfully transmitted about 2500 miles, this result convincing all doubters that there existed no positive limit to the distance that

might be covered by Marconi's system, the strength of the currents set up and the reliability of the instruments being the determining factors. As only seven kilowatts were used in transmitting this message, it was abundantly demonstrated that the electric energy necessary to carry on long-distance work was not of a character to interfere with other electric apparatus located near a sending station, as was at first argued by detractors of the system. Those who had prophesied numerous fires as a result of sending out such tremendous sparkings were nonplussed by evidence that a current sufficient to act upon a coherer at fifty miles would not set on fire a piece of paper placed directly in the spark of the transmitter.

The record message referred to, which occupied four minutes in sending, read as follows:

"HIS MAJESTY KING EDWARD VII., London, by Marconi Transatlantic Wireless Telegraphy:

"In taking advantage of the wonderful triumph of scientific research and ingenuity which has been achieved in perfecting a system of wireless telegraphy, I extend, on behalf of the American people, most cordial greetings and good wishes to you and to all the people of the British Empire.

THEODORE ROOSEVELT.

"Washington, D. C."

It seems that Marconi did not expect at the time of sending that he could make the distance direct, but intended to transmit the message to Glace Bay and thence have it repeated to Poldhú. While he was communicating with Glace Bay, the operator there sent him back word that he had just heard from Poldhu that their instruments had received the message at the time Marconi was transmitting it to be received by Glace Bay.

Marconi's early apparatus consisted of a modified form of Hertzian oscillator, which had one sphere of the spark-discharger earthed and the other connected to an elevated and practically vertical wire. When sparks are discharged by this apparatus, some of the electric energy is thrown off in the form of a displacement wave in the ether, and the vertical wire radiates electric waves. The regulating of the spark action by the strokes of a Morse telegraph-key causes the waves to vary so that they reproduce at a receiving station in the Morse alphabet, and may be read by any telegraph operator in dots and dashes.

The receiver used previous to 1903 was a coherer, a simple instrument, consisting essentially of a small glass tube plugged at either end with a wire, and having between the wires a gap partly filled with filings, preferably a mixture of silver and nickel filings.

The wire at one end of the coherer is earthed, and the other is run up vertically to catch the waves. When such a coherer becomes affected by a Hertzian wave, the filings arrange themselves in a line and form a connection, that may be registered by an ordinary telegraph recorder or be heard in the telephone. The wave having passed it is necessary to throw the filings out of line by tapping the coherer, this tapper being called a decoherer. The Hertzian wave from a long distance is too weak of itself to operate a telegraph instrument, but it is strong enough to affect the filings, and when these connect the wires at either end of the coherer, a local current is brought in as a relay, and this in turn causes another stronger current to operate the recording instrument and also the decoherer.

Marconi signal stations have been constructed in several different ways, one method being as follows: Four towers are erected at the angles of a quadrangle, and run up to a height of about 250 feet, at a distance apart of perhaps 160 feet. These towers are well braced with wires and connected at the top by bridges. From each of the four bridges depend on either side sets of fifty copper cables, which converge towards a central building, in which they terminate. These copper cables are the elevated wires that catch the waves of messages received, and that radiate the waves of messages sent out.

In order that messages sent by various stations may not conflict, tuning is resorted to. This means the use at a given sending and receiving station of apparatus that responds to a given period of vibrations, just as one tuning-fork responds to another of like character, or as a piano-wire sometimes responds to the note of a violin. Tuning-forks and piano-wires vibrate the air, and in wireless telegraphy the ether must be vibrated; otherwise the principle involved is the same. A number of tuning systems have been devised, and that of Professor M. I. Pupin, of Columbia University, has been taken up by the Marconi Company, which has the exclusive license for its use. This system provides for the construction of several branch electric circuits in connection with a given line, the arrangement being such that each circuit corresponds to a certain pitch of frequency. Then by impressing an alternating electromotive force on the line, or on the ether, as the case may be, the corresponding receiver alone will respond.

The principle involved in this system of tuning is said to have been thought out by Marconi and by Professor Pupin at about the same time, each, of course, without knowledge of the other's efforts. By having a series of such transmitters and receivers at stations, different messages can be sent by the corresponding instruments over

the same radiating and receiving wires, thus multiplexing the entire system. While the tuning system is preferred for land work, at this writing it is not applied to the installations in ships, for the reason that it is considered to be an advantage for every ship so equipped to be able to communicate with every other ship. In time, probably, ships will be equipped with a general system, that can be received on any ship or on land, and also with a system made private by tuning for such as it is desired to communicate with.

A number of coherers have been invented, one, called the Italian navy coherer, having two carbon electrodes, enclosing two drops of mercury, separated by a small iron cylinder. This requires

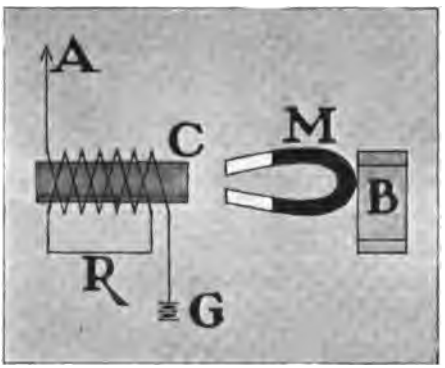


Diagram of Marconi's Magnetic Detector.

no tapper, being self-decohering. It is used with a telephone, and increases the speed of operation. But the development of coherers has been checked by the bringing out of several better instruments for a similar purpose, commonly called wave detectors. Marconi's magnetic detector is thus described by himself:

"On a core (*C*) of thin iron or steel, but preferably hard drawn iron, are wound one or two layers of thin insulated copper wire. Over this winding insulating material is placed, and over this, again, another longer winding of thin copper wire contained in a narrow bobbin. The ends of the winding nearest the iron core are connected, one to earth (*G*) and the other to an elevated conductor (*A*), or they may be connected to the secondary of a suitable receiving transformer or intensifying coil, such as are employed for syntonic wireless telegraphy. The ends of the other winding are connected to the terminals of a telephone (*R*) or other suitable receiving instrument. Near the ends of the core, or in close proximity to it, is placed a horseshoe magnet (*M*) which, by a clock-work arrangement (*B*), is so moved or revolved as to cause a slow and constant change or successive reversals in the magnetization of the piece of iron."

This detector has proved much more sensitive and reliable than the coherer, and permits a speed of thirty or forty words a minute, which Mr. Marconi thinks can be increased to several hundred words a minute.

Wireless telegraphy undoubtedly has a bright future for land use over short distances, especially where a multiple service is desired. For instance, the Associated Press might serve ten newspapers in a large city with the same despatches at a single sending, each newspaper having a receiving station. Or large business houses desiring any sort of special information promptly and regularly might receive it in the same way. This is a sort of service that cannot be had from either the ordinary telegraph or the telephone, and is a field in which a wide development may be expected.

The world is beginning to appreciate what wireless telegraphy can accomplish and what must not be expected of it. The great public usually expects too much of an invention that suggests startling innovations. There is no good reason for believing that wireless telegraphy will put the submarine cables out of business. The electric light did not kill off the gas companies, nor did gas put out the kerosene lamp, nor the lamp blow out the tallow candle. All of these lights continue to have their uses, and the ocean cables have theirs, just as have the telegraph and the telephone lines, and the wireless telegraph will find a place for itself without seriously disturbing either.

The drawbacks to the wireless systems come principally from interference, and there have been those who exclaimed against the whole thing because it has been possible for one rival company to send out strong currents near the receiving station of another company and thus mix up its messages so that nothing could be understood. The reports of certain yacht races were killed in this way, and during naval manœuvres it has been possible for rival fleets to cripple each other's wireless service.

Of course the desired remedy for these difficulties is improved mechanism, preventing interference. It goes without saying that such improvements will be made, and that, even if they fail to wholly protect this sort of communication, there are other ways of securing protection from annoyance. International agreements have already been proposed for the purpose of establishing regulations that will prevent maritime nations from interfering with one another's service. The common-sense of the parties using wireless telegraphy is bound to make them have a decent regard for each other's rights, if only for the purpose of freeing themselves from inconvenience.

There have been many, especially in England and Germany, who objected to giving Marconi the credit of making a success of wireless telegraphy. In the United States he has generally received fair treatment in this regard. Of course, Marconi did not invent the whole system, any more than Edison invented all there is to the electric light, or Bell all there is to the telephone; but Marconi did do more than any other man to make wireless telegraphy a commercial proposition. The fact that Marconi was able to bring into a partnership with himself such men as Edison and Pupin shows how strong is his position with the most gifted students of electricity. Professor Elihu Thomson, who is eminently qualified to be a judge as to the credit due Marconi, has said:

"I believe Marconi is entitled to all the credit he has been given for wireless telegraphy. He has done all the practical work and developed the theory. Others have theorized on it, but Marconi has put the thing to practical use. I have given this matter a good deal of study, and I am convinced that Marconi deserves all he has got."

Although Marconi has been more successful than any other inventor in the field of wireless telegraphy, there are others who have done excellent and successful work. The Slaby-d'Arco system is being introduced on the European continent and used in the United States navy, and the Lodge-Muirhead system has been installed on the ships of the English cable companies. This last-named system is the result of the combined efforts of Sir Oliver Lodge, principal of the Birmingham (England) University, and of Dr. Alex. Muirhead, a wealthy manufacturer. It was Dr. Lodge who, in June, 1894, demonstrated in London, at a lecture, that Hertzian waves could be detected by suitable receivers through solid walls. Since that date his experiments continued, and he is recognized as perhaps the most advanced student of wireless telegraphy in England. Instead of a coherer he employs as a receiver a small fine-edged steel disk that is rotated by clockwork upon a globule of mercury, there being a thin film of oil between the disk and the mercury. The oil acts as an insulator under normal conditions, but when an oscillation or wave is received from the transmitting station the film of oil breaks down and a contact is established between the disk and the mercury, thus completing a circuit in the instrument, and bringing a siphon recorder into operation. The Lodge-Muirhead system employs elevated wires to radiate and receive the waves, in a manner similar to the Marconi system.

Radically different is the method devised by Axtel Orling, a young Swedish electrician, operating in conjunction with a London

engineer, J. T. Armstrong. High masts, coherers, and induction coils are dispensed with, the apparatus being of the simplest character, and perhaps destined to come into use as a cheap portable outfit for local use. It can be encased in a box seven by eight by four inches, and weighs but half a dozen pounds. The case includes a battery of eight volts, very little power being required. To put the apparatus in operation out-doors, two iron stakes are driven into the ground to a depth of about eighteen inches and about twelve feet apart. A wire being tied to each stake is carried to the positive and negative poles of the battery and attached by contact screws. The operator puts a telephone receiver to his ear, and can hear messages sent by similar apparatus from a distance of twenty miles. The apparatus can be used in a moving carriage, if it has iron tires, by connecting the wires to a roller pressing against one of the tires.

The Orling apparatus is based upon the capillary attraction of mercury when affected by an electric current. A siphon is filled with mercury in such a manner that one leg is almost ready to drop a globule of mercury upon the lever of a Morse key. When a current coming through the earth affects the mercury, a drop falls on the lever, and the Morse key ticks, and is heard by the person listening at the telephone receiver.

A most interesting application of the Orling apparatus has been devised and tested in miniature by Messrs. Orling and Armstrong. A model of a submarine boat about six feet in length was equipped with the apparatus and its manœuvres directed from the shore. The operating instrument on the craft is made to control the rudder instead of a Morse key, and the man on shore operates a little steering-wheel, that is connected to earth, with the sending apparatus. The bow and stern of the iron boat act as positive and negative poles, and the water carries the current even better than the ground. The rising and diving of the submarine boat may be directed as readily as the right and left steering. In fact, the experiment shows the practicability of directing a submarine boat of good size from the deck of a battle-ship; or a torpedo may be substituted for a submarine boat, and steered under water to the hull of an enemy and there exploded.

Perhaps in the future, when great naval forces meet, there will be a long-distance skirmish with torpedoes and submarines, the powerful fighting craft being afraid to close in because of the unseen foes beneath the waves. Messrs. Orling and Armstrong go even farther than this in suggesting the deadly possibilities of their system. A harbor or coast may be protected with submarine

mines of dynamite, each carrying an apparatus tuned so that it can be set off only by its appropriate wave. The engineer on shore has a chart of the mines, and a set of apparatus, each one tuned to a corresponding mine. When a vessel of an approaching fleet rides over a mine, he touches off the appropriate receiver, and the enemy is no more. There are no wires running down the beach, as with the systems now in use, to warn the enemy as to the probable nearness of such mines; consequently no safety can be obtained by sending a party ashore to cut such wires. The enemy can avoid the danger only by keeping away from the mines or capturing the headquarters of the operator, and, as he may be in any house within twenty miles, that is out of the question.

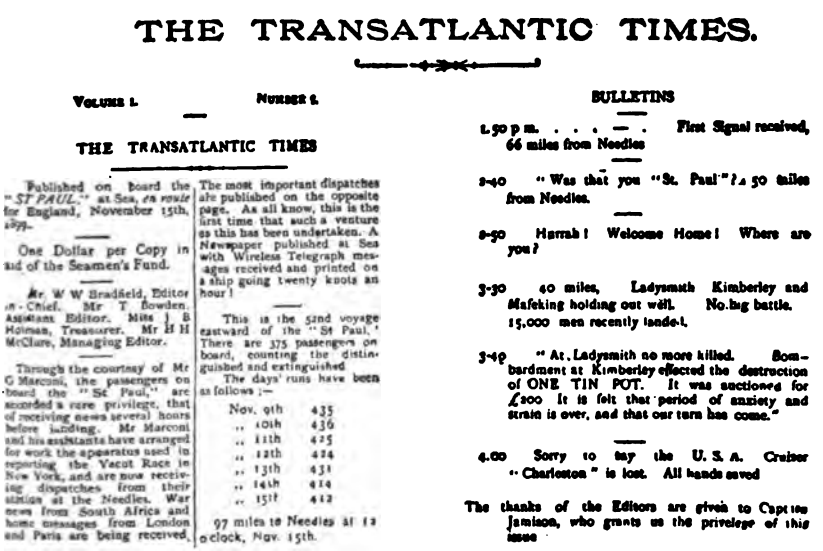
This system of using electricity without wires has also been tried for operating the semaphore signals of a railway, and found to operate satisfactorily at a distance of five miles, making it possible for railways to send warning signals to a considerably greater distance than with present means. Electric lamps can also be lighted from a distance by this system, the method of lighting requiring only the touching of a button.

Another wireless system has been originated by Professor John S. Stone, of the Massachusetts Institute of Technology, who claims a selective method that prevents all interference. He established a station at Lynn and another at Cambridge, some eight or ten miles apart. Though each station is within a few hundred feet of electric-car lines carrying strong currents, there has been no interference. Mr. Stone considers that the success of his system will lie in its selectivity. By this is meant the capacity of a wireless system for sending, from a given transmitter to a given receiver, a message that cannot be taken by any other receiver or interfered with by the sending out of other strong currents in the vicinity. Professor Stone is able to send a number of messages simultaneously from one station, as does Professor Pupin. The Stone system is designed for short-distance service, relays being used when it is desired to send messages to considerable distances.

A German system for short-distance work was described about January 1, 1903, in *Physikalische Zeitung*. The inventor is Herr Blockmann, and he employs certain dark rays of the ether, designating his system as ray telegraphy. The apparatus is much like a heliograph, except that it employs other rays than those of light, and hence will work in the dark or in a fog, when the heliograph would be useless. Mountains, tall buildings, and the like interfere with the rays, and there must be clear space between the sending

and receiving stations. Large mirrors, about thirty-two inches in diameter, are employed to send and receive the rays, which are reflectible, as is light. The apparatus permits simultaneous messages to be sent without conflict. If the mechanism prove inexpensive and not easily put out of order, there would seem to be a future for this system.

" Wireless" newspapers are among the first products of wireless telegraphy. The first of these was printed September 15, 1899, and a reduced copy is shown in the illustration.



THE TRANSATLANTIC TIMES.

VOLUME I. NUMBER 1.

THE TRANSATLANTIC TIMES

Published on board the "ST PAUL," at Sea, *en route* for England, November 15th, 1899.

One Dollar per Copy in aid of the Seamen's Fund.

Mr. W W Bradfield, Editor in Chief. Mr T Bowden, Assistant Editor. Miss J B Holman, Treasurer. Mr H H McClure, Managing Editor.

Through the courtesy of Mr G Marconi, the passengers on board the "St Paul," are accorded a rare privilege, that of receiving news several hours before landing. Mr Marconi and his assistants have arranged for work the apparatus used in reporting the Yacht Race in New York, and are now receiving dispatches from their station at the Needles. War news from South Africa and home messages from London and Paris are being received.

The most important dispatches are published on the opposite page. As all know, this is the first time that such a venture as this has been undertaken. A Newspaper published at Sea with Wireless Telegraph messages received and printed on a ship going twenty knots an hour!

This is the 52nd voyage eastward of the "St Paul." There are 375 passengers on board, counting the distinguished and extinguished.

The days' runs have been as follows:—

Nov. 9th	435
,, 10th	436
,, 11th	425
,, 12th	424
,, 13th	431
,, 14th	414
,, 15th	412

97 miles to Needles at 12 o'clock, Nov. 15th.

BULLETINS

1.50 p.m. . . . . First Signal received, 66 miles from Needles

2-40 "Was that you "St. Paul"? 50 miles from Needles.

2-50 Hurrah! Welcome Home! Where are you?

3-30 40 miles, Ladysmith Kimberley and Mafeking holding out well. No big battle. 15,000 men recently landed.

3-40 "At Ladysmith no more killed. Bombardment at Kimberley effected the destruction of ONE TIN POT. It was auctioned for £200 It is felt that period of anxiety and strain is over, and that our turn has come."

4.00 Sorry to say the U. S. A. Cruiser "Charleston" is lost. All hands saved

The thanks of the Editors are given to Captain Jamison, who grants us the privilege of this issue

The First "Wireless" Newspaper.

Close on the heels of the wireless telegraph comes the wireless telephone. It is apparent that, as the Morse code is received by the ear at the telephone in the wireless system of telegraphy, it must be mechanically possible to make the sounds of the human voice reproduce themselves in a similar way, being carried by the Hertzian waves. Wireless telephony is yet in a theoretical stage; but Frederick A. Collins, of New York, has developed an interesting system that promises rich results in the near future. He began experimenting in 1900, at first separating his instruments by only eight or ten inches, and gradually increasing the distance, as he learned the conditions and the means of overcoming obstacles, until he succeeded with stations separated by several miles. He obtains

extreme sensitiveness in his receiver by multiplying the number of diaphragms, using varied thicknesses. He says:

"My method is to transform a direct electrical current of low voltage into a current of high potential, being approximately 20,000 volts. The current is also converted into an alternating discharge of high mechanical frequency. When a word is spoken into one of my transmitters, it is transformed into mechanical vibration equalling 800 to 1000 per second. This varies the current which is then superimposed on the alternating current.

"I have found that, when such a current is projected simultaneously into the air and earth, energy is propagated through space by the ether in the air and in the earth. The distance to which this electrical energy is transmitted may be thousands of miles, but heretofore the difficulty has been to find an instrument of sufficient sensitiveness to indicate these impulses. I have, however, overcome this by devising a most sensitive detector, which, in connection with the receiver, makes it possible to reproduce audibly the voice spoken into the transmitter with no connection other than the elements themselves."

Mr. Collins made successful experiments with his system on ferry-boats plying between New York and Jersey City, but became convinced that it was not practical for any considerable distance.

These experiments all indicate that before many years it will be common to accomplish things at a distance by means of wireless telegraphy and telephony with the same facility that we now employ the wires, as for call-bells, private telephoning, operating stock tickers, and other modern conveniences. The day when space is to be annihilated is nigh at hand. Quoting somewhat freely the words of an eminent London engineer, speaking in 1897:

"We are gradually approaching a time when if a person wanted to call to a friend he knew not where, he would call in a loud, electro-magnetic voice, heard by him who had the electro-magnetic ear, silent to him who had it not. 'Where are you?' he would say. A small reply would come, 'I am at the bottom of a coal-mine, or crossing the Andes, or in the middle of the Pacific.' Or, perhaps, in spite of all the calling, no reply would come, and the person would then know his friend was dead. Let them think of what that meant, of the calling which went on every day from room to room of a house, and then think of that calling extending from pole to pole; not a noisy babble, but a call audible to him who wanted to hear and absolutely silent to him who did not."

In quite another direction the experiments in wireless telegraphy are adding to the sum of human knowledge. Professor Thomas Tommassina has demonstrated that the human body is a natural receiver for wireless telegraphy, the waves affecting the brain so that it becomes a coherer and automatically decoheres itself. Mr. Collins, the inventor of the wireless telephone, has made a series of tests along this line, which suggest some scientific basis for telepathic communication,—that is, the transmitting of intelligence from one human brain to another without visible means of commu-

nication. Mr. Collins's investigations led him to the conclusion that the electric waves reaching and affecting the human body caused the nerves to approach, which suggests that the nerves are largely electrical in their operation, a theory held by many. He also proved that the brain acted similarly to a coherer both in life and after death, which perhaps accounts for the familiar experiment of making the legs of a dead frog twitch by applying an electric current to the nerves. Another conclusion of Mr. Collins was that the fear many persons evince in the presence of a thunder-storm is not due to cowardice, but to the fact that their nerves are unusually sensitive to electric waves, rendering them incapable of obeying normal judgment during the period of the electrical overcharge.

Such speculations tend to lead us to the conclusion that mankind is destined eventually to master all knowledge, and that our present learning simply enables us to gain a glimpse of the wealth of wonderful things awaiting discovery by those who study Nature's laws, and seek to control events and operations by placing a guiding hand on the helm of the Universe.

THE KINGDOM OF IRON AND STEEL

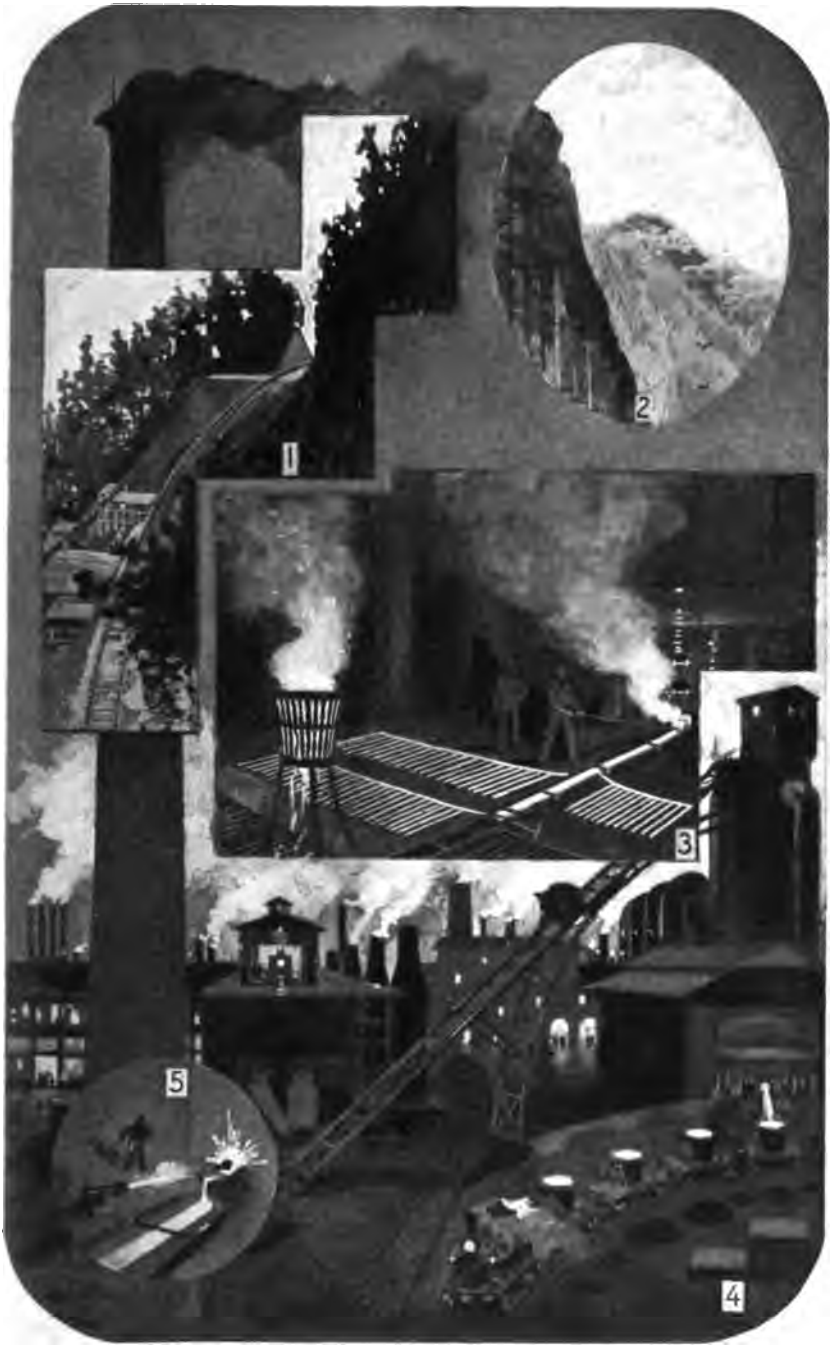
UNQUESTIONABLY the iron and steel industry is the most important in the world, not only in volume and value of products, but in its relations to other industries dependent upon the manufacture of ferric materials. Just as the printing-press is essential to maintain education and spread intelligence, so is the blast-furnace requisite to the supplying of the means for carrying on nearly all other existing industries.

We could exist as shepherds or hunters or fishers without iron; we could build houses, after a fashion, and clumsy boats, like the ancient Norsemen; but we should have to deprive ourselves of ninety-nine out of every one hundred conveniences now deemed necessaries if we should undertake to do without iron—or steel, which is simply a grade of iron and ought not to have a distinct name.

How much of our modern civilization is due to the introduction of iron we do not know; but of a certainty without this useful metal we should be reduced to a state approaching barbarism. All our machines are made of iron, and if they were made of any of the softer metals they would not only cost much more, but would wear out so soon as to be nearly worthless. Copper, tin, aluminum, nickel, etc., are all very well for certain purposes, but those who handle them and work in them know that for the purpose of machine-building they would be little better than so much wood.

Without machines we should be paddling around in little dug-outs, shooting wooden arrows at game, or tilling the soil with wooden plows, like the natives of some benighted lands. If the world were called upon to give up all of its gold and diamonds or all of its iron and steel, the precious stones and yellow metal would go first with a haste equalled only by the strenuousness of the demand.

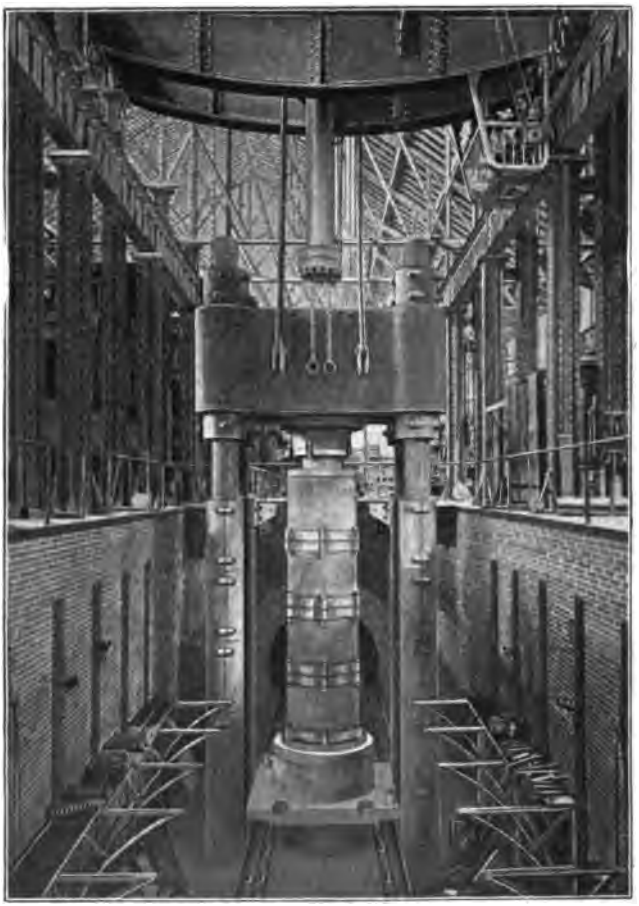
Confining ourselves now to the mere production of iron and steel, let us see what it means to the United States. The last census shows an invested capital of over $600,000,000, with an annual product of over $800,000,000; and, notwithstanding the vast amount of work performed by machines, there is an army of a quarter of a million men employed in the industry. This great business is confined to less than seven hundred establishments, the number being less than it was twenty-five years ago, owing to the



Iron and Steel Manufacture.

1. Surface iron mine in Georgia. 2. View in iron region of Tennessee. 3. Pig-iron manufacture in a small foundry. 4. Blast-furnace system of manufacturing pig iron on a large scale. 5. Plugging furnace with clay-gun.

consolidation of firms and companies. The capital invested is almost five times what it was in 1870, and the amount of wages paid is three times as great; the cost of materials used, which was one and a third millions in 1870, increased to five and a quarter millions in 1900. The States of Pennsylvania, Ohio, and Illinois take the



End View of Steel-Casting Pit, Bethlehem Steel Works.

lead in this industry in the order named, Pennsylvania contributing more than one-half of the total, though employing less than one-half of the wage-earners. Ohio has $86,000,000 invested in the industry, and Illinois $43,000,000. No other State except New Jersey has as much as $20,000,000 invested in the production of iron and steel.

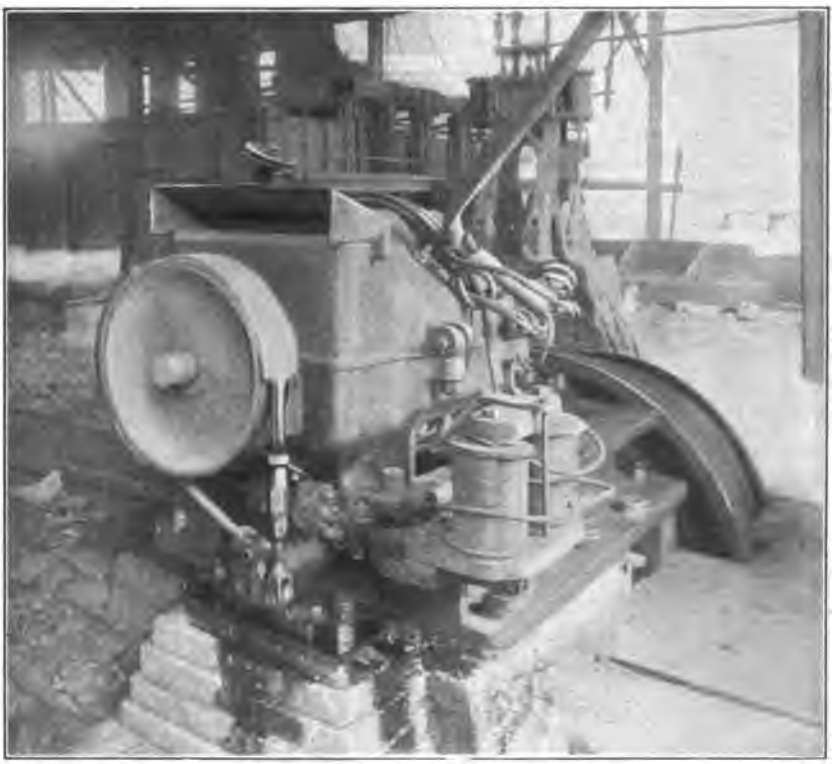
The growth of the industry as measured by the tons of metal produced is very much greater than when measured by the increase in dollars; in 1870 our iron and steel mills turned out only three and a quarter million tons, while in 1900 they turned out almost thirty million tons, an increase of over eight hundred per cent. During these years of phenomenal growth the cost of iron and steel to the consumers was very much reduced, owing to the installation of labor-saving machinery. In 1870 the average price of iron and steel products lumped together was $63.49 per ton; in 1886 the figure came down to $45.70 per ton, in 1890 to $29.43 per ton, and in 1900 to $27.25 per ton. In 1895 the price was less than in 1900, owing to depressed commercial conditions, but, leaving this feature out of the calculation, it will be seen that present prices are about forty per cent. of what they were thirty-five years ago.

During the period between 1890 and 1900 there was a great movement towards consolidation of interests, and very many of the establishments began to operate in the manner popularly known as a "trust." In 1900 there were fourteen companies which owned or operated 136 blast-furnaces, having an annual capacity of nearly 12,000,000 gross tons of pig iron, which is considerably more than half the product of the whole country; seven companies had control of 41 Bessemer-steel plants, with a capacity of 8,000,000 tons, or seventy per cent. of the capacity of the whole country; twelve companies controlled 142 open-hearth furnaces, with a capacity of over 3,370,000 tons of steel, or sixty per cent. of the total capacity of the country; while nineteen companies controlled 158 rolling-mills, with a capacity of 16,500,000 tons of rolled and forged iron and steel, or over sixty per cent. of the total capacity of the country. From this it is apparent that, while there are nominally nearly seven hundred establishments throughout the United States engaged in the production of iron and steel, in reality some twenty companies, operating under mutual ownership or agreements, control the industry, so as to be able to dictate to the public.

One-half of the capital invested in the industry is in buildings, machinery, and tools, and the other half in land, cash, and sundries, this proportion having been preserved pretty evenly for the past twenty-five years. Almost seventy-five per cent. of the capital is invested in rolling-mills and steel-works, and twenty-five per cent. in blast-furnaces, the remaining fraction (about one per cent.) being in forges and bloomeries. This last-mentioned portion of the business is going into a decline, owing to changed methods of manufacture. In 1900 twenty-nine new steel-works and rolling-

mills were being constructed, and five new blast-furnaces. At this date (1904) the steel-mills are suffering from over-production.

It is interesting to note that the mills and furnaces of the United States consumed thirty million tons of coal and coke in 1900, this being nearly double the amount in 1890. The use of oil for fuel showed a decrease in this industry during the ten years named, there being 1,300,000 barrels used in 1900. Of the $67,000,000 spent annually for fuel, one-tenth is expended for natural



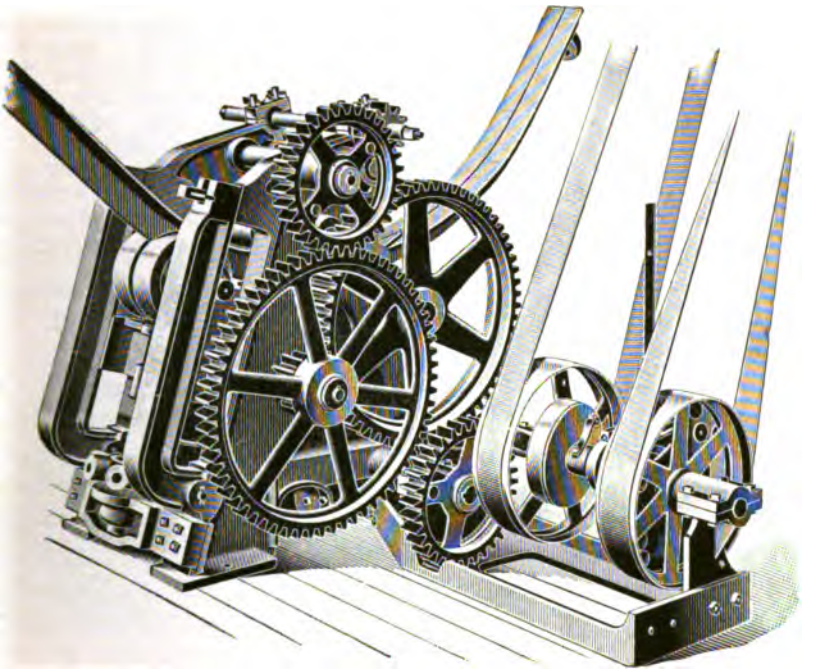
Courtesy of Engineering Magazine.

Motor Hauling Reheated Blooms to Rail Mill.

gas. The products of the blast-furnaces in 1900 amounted to 14,500,000 tons of castings, including spiegeleisen and ferromanganese; and the production of rolled and forged iron and steel castings by the rolling-mills and steel-works in 1900 was over 15,000,000 tons. Allegheny County, Pennsylvania, produced over 8,000,000 tons of iron and steel products in 1900, and Cook County, Illinois, nearly 2,000,000 tons, these two counties furnishing about one-third the entire product of the country.

George Westinghouse, speaking, at a banquet in London, of American progress in steel-making, said in part:

"An illustration of what has been accomplished by the use of electricity is seen in the Homestead mills of the Carnegie company, where they produce with about 4000 men three times as much steel as the Krupp works produce with 15,000 men. The results are simply wonderful. You can start there to-day, in a building containing steel-melting furnaces, and you will there see three men mounted on a car with the charging apparatus which is moved and operated by electricity. With a few movements of this ingenious contrivance three men charge twenty furnaces, which prior to the use of electricity would have required the labor of over 200 men.



A Steel-Bending Machine.

"You may go into the yard of the Homestead mills where they pile the metal in stock. This yard is covered by a system of overhead cranes, and the result is that not only here, but in the mill, and in every other place, you may see great weights lifted and many undertakings going on without a single man exerting himself a bit—working not working half as hard as I am working now.

"I took some English friends to Homestead, where they turn out 750 tons of plate girders per day. The mill was in the shape of an 'L.' We went into the short end of the 'L' where the furnaces were fed by natural gas, of course requiring no stokers. The end at which we entered had a rather low roof, and there was a slight contrivance like a battering-ram in front of the furnaces; two workmen were sitting down eating their dinners near by; no one else was present. Apparently the mill was not in operation. But we went through the mill, which was about 200 feet long; and suddenly heard a rattle and then saw a

truck approaching loaded with a big ingot. No one touched the truck or the ingot. The load came to a platform, the crane overhead dropped a pair of tongs and quickly put the ingot on the roller-table, and as it moved along to the great rolls it was automatically kept in place. The adjusting screws of the rolls were turned by little electric motors, and not a man in that house did a bit of work. It was just as easy as what you are doing now—looking on! We went back to the furnaces. There was a fifteen-year-old boy seated in a little place called the 'pulpit.' He was able, merely by the movement of levers, to open at will any of the furnace doors and move the car along. And we saw this car come in front of a furnace, and the charging machine approach, and take out of the open furnace a hot ingot which was dropped on the car and moved off to its work. There was this boy doing absolutely no hard work, and his mill was turning out 750 tons of steel plate each day. My English friends said, 'England has no chance in competition with such methods.'

"At the Carnegie mills we went to see three blast-furnaces. They were making 1800 tons of pig-iron in twenty-four hours. We saw only two or three men on a truck which was moved automatically. These men were letting the ore run from shoots and mixing it in the required quantity, and when they had filled a truck, it was carried up and its contents dumped into a furnace, whence it returned for another load. They were running the metal into an immense receptacle into which the metal from all three furnaces was mixed. From this place the metal was taken as required, put into a special tank, mounted on a car and taken to Homestead, two or three miles away, to be poured into the furnaces; one heating only was required.

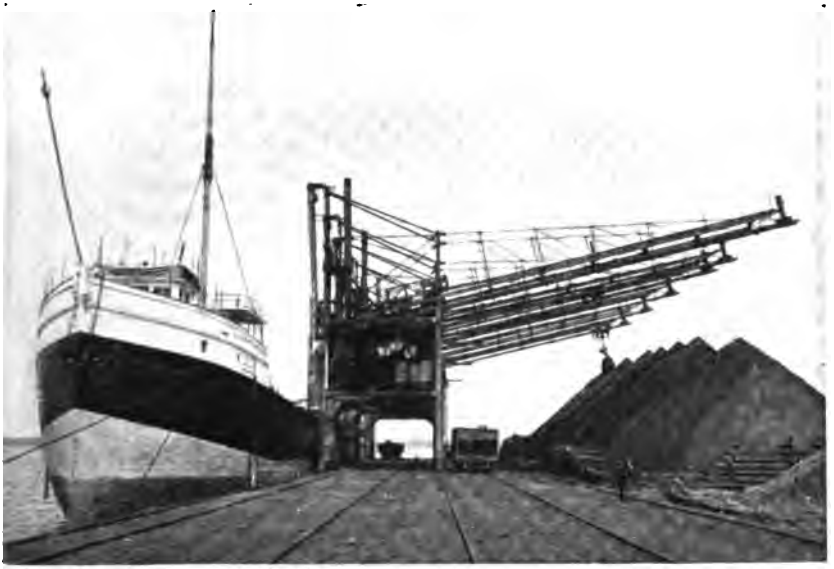
"Now all this sort of thing came about in America because of our necessities. We hadn't men enough to do our work. There was a premium in favor of those who could invent machines to work and thus supply the deficiency."

The Carnegie Steel-Works, consisting of three great plants,—the Edgar Thomson, the Duquesne, and the Homestead Steel-Works,—are all located in Allegheny County, and are the largest in the world; in fact, probably no other plant exceeds any one of the three. The Thomson works produce 700,000,000 tons of steel rails in a year, while the Duquesne works produce the same quantity of ingots, and the Homestead works 500,000 tons of Bessemer-steel ingots besides 1,500,000 tons of open-hearth steel ingots. The foundry at the Thomson works produces over 50,000 tons annually of iron, steel, and brass castings. The Carnegie Company also owns the Upper Union Steel-Mills, having seven trains of rolls, which produce structural steel, plates and bars to the amount of 250,000 tons a year, while the Lower Union Steel-Mills have a product two-thirds as great. The company also owns a number of minor works.

As compared with other countries, the United States produces more pig-iron and more steel than Great Britain and Germany combined, our output of each being over forty per cent. of the world's production. No other country besides those named cuts a large figure in this industry. This contrast is the more creditable to the United States, since in 1874 we produced only forty per cent. as much iron and steel as Great Britain, and only a little more than Germany or France.

America's supremacy in the steel and iron trade comes very largely from the admirable means that have been developed for bringing the ore from the Lake Superior mines a thousand miles to the Pittsburg factories, without any real handling and at minimum cost. The reduction of this cost is the more creditable to those concerned because the ore has to be transshipped twice *en route*. There is first a railway journey to the lake, then a steamer trip, and then a railway haul of 150 miles from Lake Erie to Pittsburg.

The ore from the Lake Superior mines is taken by rail to Duluth, where the cars run out on to jetties two thousand feet long



Unloading Ore from Steamboat with Brown Conveyors.

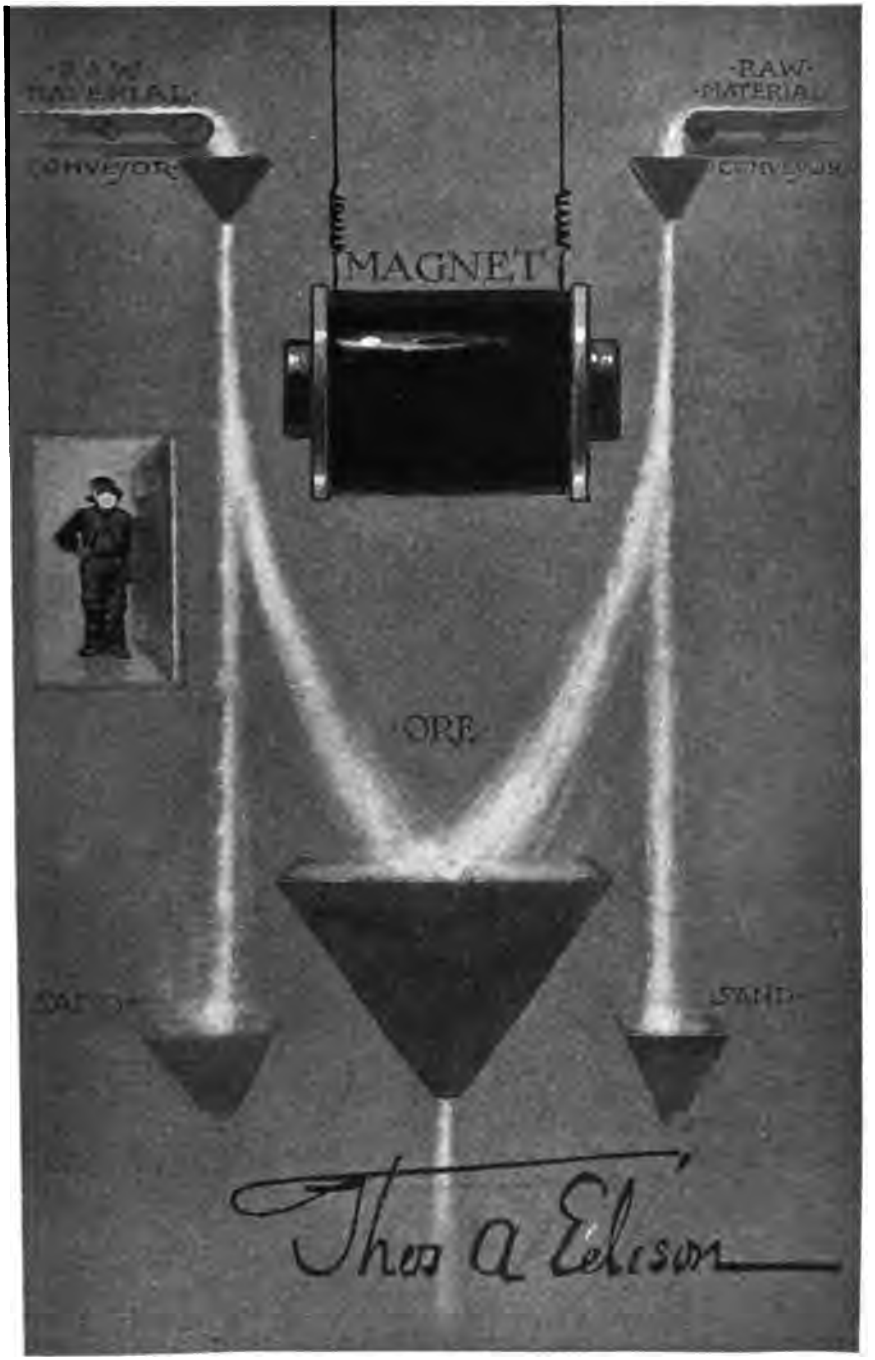
and having four tracks the entire length. On these jetties the cars discharge the ore simply by opening bottom doors and dropping it into huge bins. The ships are loaded by allowing the ore to slide by gravity from the bins into the holds, thus reducing hand labor to a minimum. The ships have numerous hatchways, and enormous spouts are led from the bins to the several hatchways of a vessel, so that the loading is done in a very brief time. Trimming machines are employed to smooth out the ore automatically, the entire operation of loading being very simple and inexpensive.

The vessels used in the lake traffic carry about 6000 tons of ore, and some of them are 500 feet long, being almost or quite

as commodious as the average tramp steamer used on the Atlantic. Nowhere else in the world are such large boats used for interior navigation. These boats traverse the often stormy waters of Lake Superior for a distance of about 400 miles, passing through the famous Sault Ste. Marie Canal to Lake Huron. This canal with its wonderful locks is described in another chapter. It is because of the ore carried through this canal that its tonnage is larger than any other canal in the world. After traversing Lake Huron the vessels pass into Lake Erie by the St. Clair Canal. Most of the ore which does not go on to Pittsburg stops at Lorain, where is located the enormous Johnson steel-plant. The machinery employed here for landing the ore consists of a series of Brown conveyors, which take the ore direct from the vessel's hold and deposit it in the stock-yard. This stock-yard is necessary to keep the plant supplied during the months when the ice stops the lake traffic. The Brown conveyor is a ponderous and wonderful machine, consisting of an enormous travelling steel bridge of a width of about 400 feet. The steel supports of the bridge are mounted on wheels running on heavy tracks, so that the entire structure forms not only a bridge but a railway. On the bridge, in a sort of lookout box, is a man who pulls levers and thus controls the whole mechanism. Wire ropes running over pulleys hoist the ore in buckets, which are carried along and emptied into the stock-yard, virtually without hand labor. To see eight or ten of these conveyors working at once from the hatchways of a large ship, and sending out the ore in buckets, weighing three-quarters of a ton each, at almost railroad speed, is a sight never to be forgotten. The cost of unloading at Lorain is stated to be a little less than one cent per ton. One of the largest plants of these conveyors is at the Illinois Steel Company's works in South Chicago, where there are nineteen that may sometimes be seen all working at once, handling ore at the rate of fifty tons per hour for each machine.

The Carnegie Steel Company maintains a port of its own at Conneaut, on Lake Erie, from which it operates a railway to the blast-furnaces at Pittsburg. Since there are no passengers or miscellaneous freight to interfere with the service, the line is worked expeditiously and economically, and the cost of carrying the ore is only a third of a cent per ton-mile.

In 1902 there were mined in the United States over 35,000,000 metric tons of iron ore, valued at $1.84 per ton, or nearly $65,000,000. This ore produced over 18,000,000 metric tons of pig iron, worth over $289,000,000, at a valuation of $16.19 per ton.



Edison's Magnetic Ore Separator. From original sketch by Mr. Edison.
The attendant shown on the left wears a filter to protect his lungs from the dust.

The Edison magnetic concentrator is a mechanism for separating the undesirable portions of iron ore from the rich metal. It receives the ore in masses of any size up to five- or six-ton boulders. These are broken up between the enormous crushing rolls, being reduced to small fragments. These rolls have on their surface steel knobs, which break into the sides of large stones and so reduce them before they are carried between the rolls. When the ore has been reduced to a fine condition, comparable to ordinary sand, it is carried by conveyors to the top of the structure and allowed to fall through a narrow crack which permits it to descend in a thin shower. To one side of this shower is placed a series of magnets, which attract those falling particles that are rich in iron, causing them to fall into a different receptacle from the remainder of the sand which contains no iron. (See illustration.)

The United States has come to be recognized as a small exporter of pig iron. Though no large quantity is at present sent out of the country, yet it has been proved that it can be sold abroad for about $10 per ton at a profit, despite the fact that it has to be delivered several thousand miles away, and it is almost certain to be sold largely whenever there is a depression in the iron trade in America. Such large furnaces as the two of the Tonawanda Iron and Steel Company, which have a capacity of 500 tons each per day, are not going to be allowed to stand idle when the home demand for iron becomes reduced. A good deal of Tonawanda iron has already been shipped to Australia, very cheap water transportation rates being obtained by way of the Erie Canal.

We not only produce pig iron cheaper than any other country, but are making a better quality, by employing casting machines in place of the old system of pouring the metal direct into sand moulds. The Uehling machine is one of the most favored; this has a series of moulds strung on an endless chain, and these are carried in rotation under the flowing stream of molten iron. After the pigs have cooled in the moulds, they are usually transferred direct to railway-cars for transportation. A somewhat similar machine has been introduced by R. H. Wainford in England, but has not made much progress.

Pig iron is manufactured in blast-furnaces in which the crude iron ore is mixed with the coal fuel, limestone, dolomite, oyster-shells, etc. Coke may be used in place of coal, or may be mixed with anthracite, or mixed with bituminous, but it is contrary to United States practice to mix anthracite and bituminous in the same furnace. The blast-furnace is a great furnace set on end, and

so arranged that air can be blown in at the bottom, up through the mass of iron, fuel, and lime, thus causing it to burn rapidly, and inducing the melting of the iron, which is drawn off at the bottom. There has been great improvement in the details of construction of blast-furnaces, and in the proper choice of fuel and flux, in order to secure the desired grades of iron. Pig iron is graded according to the purpose for which it is to be used, as Bessemer, basic, foundry, forge, etc. The modern blast-furnace plants are run at great speeds as compared with those of earlier years, and three thousand tons per week is not now considered an astonishing

A Solid Ingot of Compressed Steel before Boring.

output for a blast-furnace, although in 1879, when Edgar Thomson secured a yield of 650 tons in a week, this was held as a remarkable record. This great gain in the speed of production was brought about by building the furnaces so as to stand increased heat, and applying more blast to hasten the melting. The rapid driving of furnaces in America was at first regarded by foreign manufacturers as a ruinous practice, but when they learned that our furnaces stood up to the work, they gradually began to imitate our methods. Designers of blast-furnaces now direct their attention largely to the saving of fuel while maintaining conditions essential to rapid production.

In order to operate a blast-furnace by the modern forcing process, there has been devised a remarkable machine known as the clay-gun, whose purpose is to stop up the tap-hole at the bottom of a blast-furnace when it is desired to stop drawing off molten iron. (See 5 of the illustration of "Iron and Steel Manufacture.") Since the mass of molten iron accumulated in the bottom of a large blast-furnace has great pressure, and the door or tap-hole has to be stopped with clay, as an iron door would burn out, it will be understood that stopping off the flow of melted iron, when a pig-casting machine has been filled, is a delicate and difficult process. The clay must be applied promptly and in large quantities with considerable force. The clay-gun does this by firing a number of large

Transferring Ore from one Railway to Another.

balls of clay at the tap-hole until it is blocked, steam pressure being used for the discharge.

An English expert, who described the operation of the Carnegie Company's blast-furnaces at Duquesne for the London *Times*, explains their operation thus graphically:

"The Americans make a deliberate practice of driving their furnaces, as they expressively put it, for all they are worth. In order to smelt ironstone the ore, the coke, and the limestone used for flux are charged into the top of the furnace. The coke burns, the iron melts out from the ore, and the waste matter combines with the limestone to form the product known as slag. What is the exact nature of the chemical reactions needed to produce the conversion is matter of controversy between authorities; but to get the necessary heat for these reactions a strong blast of air must be sent through the furnace. In order to produce this, blast-blowing engines of enormous power are used, the air being forced in at the bottom of the furnace through tuyeres, or short iron pipes, which are kept from melting by having a water circulation. The Duquesne engines, of which there

are ten, are forty feet high. They have cylinders up to 100 inches in diameter. Each is equal to the power that can be exerted by 1800 horses and each will deliver 50,000 cubic feet of air per minute. The pressure of the blast is equal to fifteen pounds to eighteen pounds on the square inch, and it is raised by means of enormous stoves using the waste gases from the furnaces to a temperature of 2000° Fah. The working of a blast-furnace never stops. Year after year, from the time it is first lit or 'blown in,' there passes down its fire-brick throat this constant stream of ore, coke, and flux—a thousand tons a day. The red-hot breath from the blowing engine rushes upward and meets the molten stream without ceasing, until at last the mighty digestion is worn out, after gorging perhaps a million tons, and the furnace is blown down for a new lining."

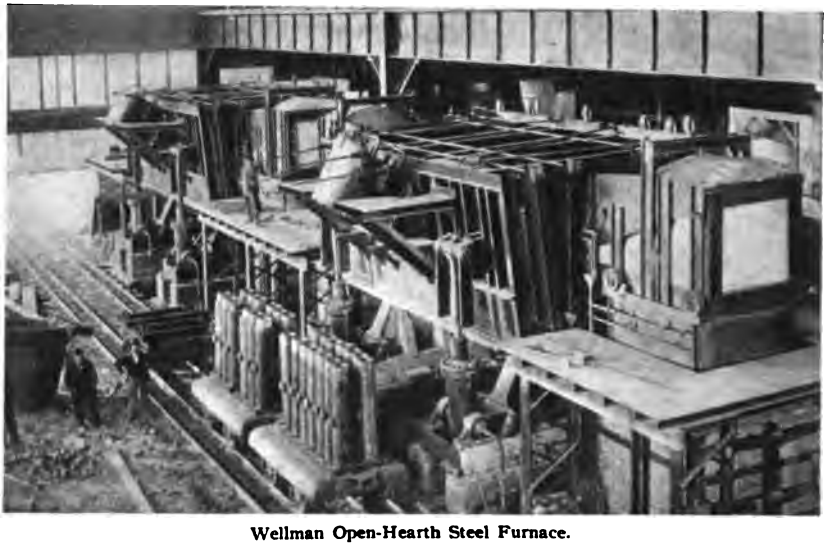
The molten iron drawn from the bottom of a blast-furnace is run into sand moulds in the floor and becomes pig iron. To be

Courtesy Engineering Magazine.

Blooming-Mill, Showing Ingot on Buggy.

used as cast iron the pigs require simply to be remelted and poured into moulds, but in order to make wrought iron, that can be hammered or pressed into various shapes, the pigs require to be treated in a puddling furnace so as to burn out the carbon and silicon. During the time it is melted in the puddling furnace the mass is stirred with tools in order to release the carbon. The metal that comes from the puddling furnace is usually in the form of a ball called a bloom, which requires some farther squeezing, rolling, or hammering to make it satisfactory as wrought iron.

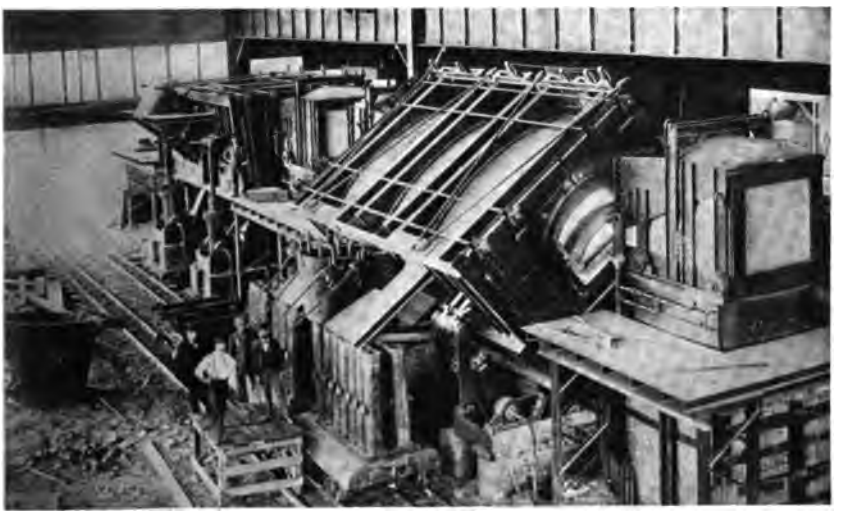
Turning now to steel-making, the open-hearth, or Siemens-Martin, type of furnace, which is in general use, has been compared to an overgrown baker's oven, strapped with iron bands. Through the door of one of the larger sizes, when open, may be seen a blinding pool, composed of perhaps fifty tons of molten metal, which is as difficult to look directly towards as to view the sun with the naked eye. These furnaces are usually arranged in a battery, parallel with which runs a railway track, upon which a charging platform is mounted on wheels. The Wellman-Seaver charging machine is the accepted type; this consists of a strong platform and framework, carrying a charging-box on the side towards the fur-



Wellman Open-Hearth Steel Furnace.

naces. The operator, who occupies a seat upon the machine, and controls it by electrical switches, tips the charging-box at the proper time, pushing it directly into the door of the furnace and turning it over. The furnace-doors are opened by hydraulic mechanism, which is wholly automatic, the one man on the machine being the only attendant. He is able to charge a half ton of pig, scrap, or ore, whichever is the material (for all are used in producing mild steel), in a few seconds' time. It is machinery of this sort, of which there is so much in the modern steel-works, that has enabled the great corporations to pay millions upon millions of dollars in annual dividends, and yet at the same time sell their product to the public so low as to distance competition.

When the metal in an open-hearth steel-furnace is ready to be tapped, it is drawn off from the side opposite to that on which it is charged. The two illustrations show Wellman open-hearth furnaces, with forehearths attached, one furnace being tipped to pouring position. The molten metal runs into a ladle, from which it may be poured into moulds to form ingots. The average ingot for rolling into plates is about three by four feet, and a foot thick, and weighs 5000 pounds, although ingots of 20,000 and 25,000 pounds are not uncommon, as in making armor-plate. The ingot-moulds are placed on low trucks and drawn away by a small locomotive.



Wellman Open-Hearth Furnace, Tipped for Pouring.

After they have sufficiently cooled, the sides of the mould are pulled off forcibly by a hydraulic-cylinder mechanism.

The American practice is to allow the ingots to cool, and then subject them to a reheating, before rolling into plates. The reason for this is that the ingot fresh from the furnace and but partially cooled may be hard enough on the outside to be rolled while still molten inside. No one can know positively the interior condition, and if rolling is undertaken it sometimes happens that the ingot spurts forth great streams of molten metal that are almost sure death to any one whom they strike. After cooling and reheating, the outside is the hottest portion, and the men who do the rolling know exactly the condition of the metal they are handling. The English practice is different, what are known as soaking pits

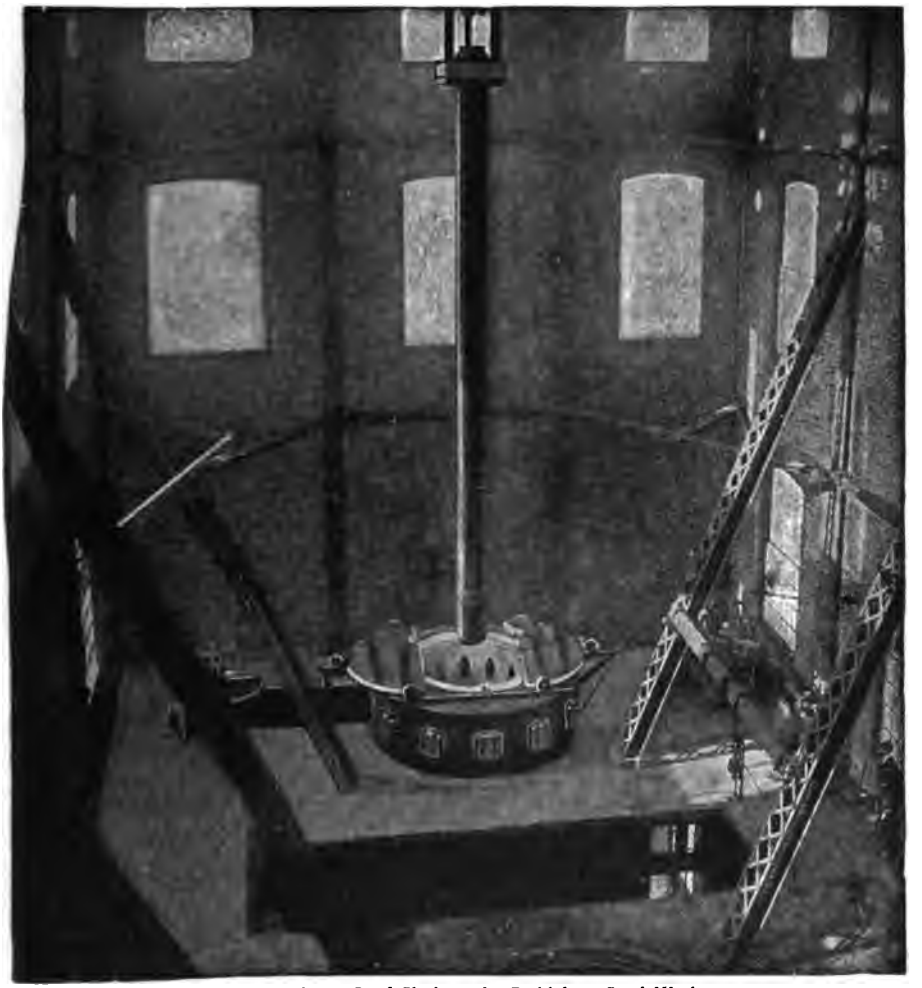
being employed, in which the ingot is partially cooled with great slowness, the theory being that the sides of the pit reflect back the heat upon the outside of the ingot, so that the temperature throughout the whole mass is pretty nearly the same. Soaking pits are used to some extent in America.

Courtesy Engineering Magazine.

Soaking Pits, Showing Electric Tongs.

Natural gas is commonly employed in the open-hearth regenerative furnaces at Pittsburg, and it has many advantages besides that of being cheap. Among other labor-saving mechanisms that should be mentioned is the hydraulic machinery for turning ingots in the

reheating furnaces; also another form of the Wellman charging machine used for charging and withdrawing blooms from the reheating furnaces. This machine picks up the bloom from the reheating furnace automatically, and carries it to the rolling-mill,



Tempering a Steel Shaft at the Bethlehem Steel Works.

where it is fed to the rollers. The magnetic cranes which lift heavy plates by magnetic attraction, saving the delay of attaching hooks or chains, are great time-savers. For handling heavy plates at the shears there are set in the floor a lot of strong rollers, mounted like the casters of a chair, only that the roller is upward; these

enable a man to handle a very heavy plate, and push it where he pleases with very little effort.

All sorts of structural steel are rolled in the Pennsylvania mills, I-beams being perhaps the most common, though they are turned out in any section demanded by the builders. As a matter of fact, however, the steel-works are mostly in advance of the builders in the matter of designing and laying out the beams for steel buildings. It is said that one concern in Pittsburg employs about a hundred draughtsmen, whose services in designing steel buildings are practically given to those interested to assist securing large orders. But rolling in the straight and rectangular forms required for steel buildings is child's play compared with the cold rolling of steel shafting of five inches' diameter and fifty feet in length; these latter are produced in Pittsburg with an accuracy that will not vary the thousandth part of an inch.

The great bulk of iron and steel for miscellaneous uses is made in the rolling-mill. A billet of white-hot metal is thrust between stout heavy rollers, which squeeze it in such a manner that it is lengthened. The continuous mills now universally employed carry the hot metal from one set of rollers to another, through smaller and smaller openings, until reduced to the desired size, when the material is cut into lengths of perhaps thirty feet for convenient handling. George Bedson, of Manchester, England, is credited with being the first to operate successfully a continuous mill. Up to his time a fifty-pound billet was about the largest size that could be easily rolled, while to-day billets of over three hundred pounds are handled with ease.

The first continuous rolling-mill was put in operation in the United States in 1869 by the Washburn & Moen Company. In this mill the metal was passed continuously between the rolls serpentine fashion, coming from the last pair of rolls at whatever size the mechanism determined. Because the continuous mill called for larger billets, furnaces were reconstructed to manufacture them. In the course of time they developed what are known as gas-fired furnaces, in which the heating was obtained by the burning of a gas obtained by the distillation of coal. Two general types of furnace came into use, the Ekman continuous furnace and Siemens regenerative furnace. Both were gas-fired, and both economized fuel, though in quite different ways. The development of the suspended roof furnace was brought about by the need of making billets that were long and slim; a billet thirty feet long, such as can be produced in one of these furnaces, is much better than one of the

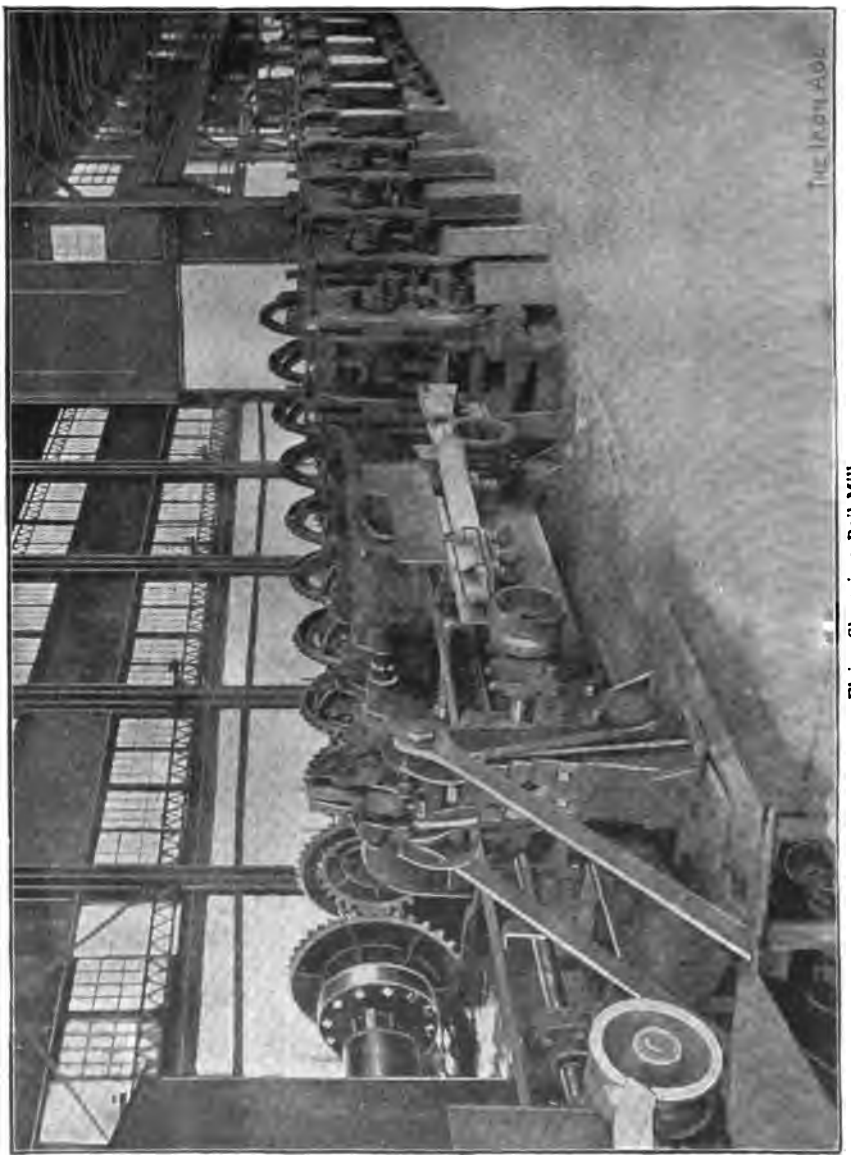
same weight fifteen feet long, there being less loss from oxidation, and the billet being more uniform throughout.

The continuous mills also forced improvements in reels, and the automatic pouring reel was produced, also the whirling pipe reel. These constructions enabled the taking up of the hot rods and protected the attendants from entanglement. But the latest and most marked improvement in rolling-mills has come from the introduction of the flying billet-shear. This became necessary for cutting off lengths of bars as they came from the rolls, because the rolling of bars several hundred feet long became a great nuisance

Flying Shear.

in handling. The flying shear is a machine for cutting the rod of metal while it is moving out of the last pair of rolls. It is designed with knives mounted upon a radial arm, and moving in company with the metal while acting upon it. After a cut the arm returns to its first position, while the bar of rolled metal continues to run out, and applies a pressure to the mechanism of the shear, actuating it for another cut. The operation of the shear is entirely automatic, when once set to cut a certain length. The production of this machine called for considerable ingenuity; the cutting had to be done in a small fraction of a second, and a clear passage made for the oncoming bar of metal, the cutting blades coming back to their work in less than one second for the next cut. The machine

had to be a heavy one, as many of the bars to be cut are quite thick. The accompanying illustration affords a fair idea of an up-to-date flying shear, manufactured by the Morgan Construction Company.



Flying Shear in a Rail Mill.

Large pieces of iron for use in machines are made principally by casting, and if an extra quality is demanded the casting is done

under pressure. The more that iron is worked and compressed, the stronger and tougher it becomes, and during recent years it has been proved that the best forging can be accomplished by heavy pressure applied during the cooling, this method now largely replacing forging by hammer for all large forgings. The last generation gloried in the steam-hammer as a wonderful tool for manufacturing large shafts, or other parts requiring to be made of wrought iron or steel, but the modern hydraulic press is rapidly putting the steam-hammer out of business.

The great Whitworth armor-plate press here illustrated was installed in the Bethlehem Steel Company's works in 1893, and is capable of delivering 7000 pounds of hydraulic pressure per square inch. Steel plates made in such a press acquire a uniformity of structure that has never been attained by any previous process.

All steel is iron, differing only in containing a larger percentage of carbon, usually with a small quantity of silicon and manganese, and often with a small percentage of some other metal, indicated by a qualifying name, as nickel-steel. The carbon gives the steel the ability to harden when cooled suddenly, the process being termed tempering.

What is now known as mild steel, or soft steel, is a product that stands between wrought iron and the hardest steels, as those used for making cutting tools. This mild steel has largely taken the place of wrought iron and is used in the construction of steel buildings, elevated railways, and the like. It is produced at the same cost as wrought iron and is materially stronger. Steel castings in many instances are replacing iron castings in the manufacture of machines, being considerably stronger, thus enabling the machines either to have a greater strength and a longer life or to be reduced in weight.

Hard steel is largely manufactured by the Bessemer process introduced in England fifty years ago. The work is done in a converter, which is an enormous bottle-like vessel, having a steel shell lined with some refractory heat-resisting material. This great vessel is mounted, slightly above its centre, on two great trunnions, so that it can be tipped. This converter is partially filled with molten cast iron, through which streams of air are discharged under pressure; this results in the air uniting with the carbon and silicon and burning them out. When the proper moment arrives, which has to be nicely judged, the blast of air is stopped, and the converter is supplied with a quantity of ferro-manganese or spiegeleisen, for the purpose of removing the sulphur and oxide of iron

Whitworth Armor-Plate Press.

with which these unite, after which the converter is emptied of its contents, which have now become molten steel.

It was formerly the custom to reheat the metal for converting in the Bessemer process; but American steel manufacturers were quick to stop the waste labor involved. They devised the direct method, in which the molten metal drawn from the blast-furnace is poured into what are known as slag bogies, which are loaded on a train and carried to the converters. Sometimes the molten metal is carried in this way for surprising distances, as at the Carnegie works, where the blast-furnaces are on one side of the Monongahela River and the converting plant is on the other, and at Duquesne, where a part of the blast-furnace product is carried four miles. It is a startling sight to see a train laden with the bogies of blazing hot metal, and one humorist on seeing it exclaimed, "Hell is going on a journey!"

Malleable iron castings began to come into use about 1880, originating in the United States, and are now sold over the entire civilized world. To understand their value one must know the practical difference between cast iron, wrought iron, and steel. Cast iron is brittle, being hard like glass, but will not bear heavy pounding, and will break before it will bend; wrought iron is ductile, and can be hammered into all sorts of shapes, even when cold; steel can also be hammered and drawn, especially when heated, but when tempered by sudden cooling it becomes brittle. Malleable iron occupies a place between cast iron and wrought iron; while it is cast, it will also bear pounding and will bend, in some cases nearly as much as wrought iron. This malleable quality in castings is produced by treatment in an annealing furnace. The great convenience of being able to cast a part of a machine according to any shape that can be made with a pattern, and yet give the casting almost the toughness of wrought iron, has opened up a great field for malleable castings. Among other things, they are used for railway couplers. Of recent years, however, steel castings have taken the place of malleable castings for many purposes.

The forming of castings of iron constitutes an important part of the iron industry. By far the greatest number of parts of machines are made of cast iron, although cast steel is coming considerably into use. The method of making castings consists in first cutting or shaping a pattern of the article to be formed in wood, and with this pattern forming a sand mould, into which the molten iron is poured, thus taking the shape of the original pattern. In order that the sand may retain the desired form or

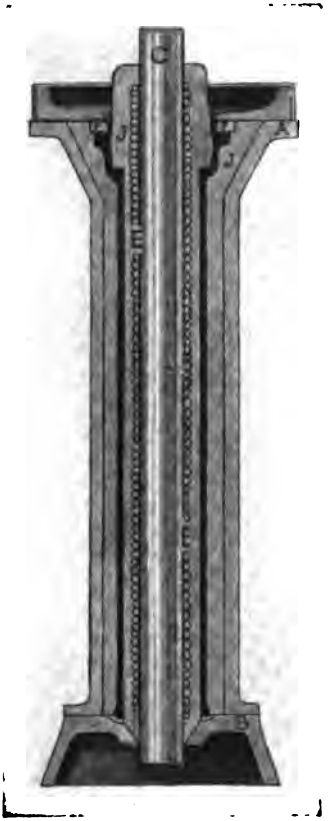
shape, it is tempered or mixed with sticky material. For making simple castings a two-part mould is used. Imagine a box like a suit-case, each half being filled with sand which has been stiffened by a sticky admixture so that it will stay in the position where it is put. Then let us suppose that a dumb-bell is embedded half-way in one-half of the case, and then that the case be closed so that the other half is likewise indented in the sand. If then the suit-case

A Steel Ingot at the Bethlehem Works.

box is opened and the dumb-bell taken out, and a small hole or holes formed in the sand to connect the cavity where the dumb-bell was with the outside, the box or suit-case may be closed, and the hot metal poured in through the small hole until it fills the cavity and thus reproduces the dumb-bell.

The casting of more complicated forms, of course, involves more labor. Take, for instance, the moulding of a length of iron pipe, of which an illustration is here presented. The centre or

core, which may be of iron, is wound around with a straw rope, E, in order to afford a grip for the tempered sand and clay which are packed around it. This core, C, being accurately centred in a base-plate, B, an outer flask, A, is placed around it, having a coating of tempered sand and clay, J, so formed that it may shape the outer side of the pipe to be cast. When the parts are in proper position, there is



Cross-Section of Mould for Iron Pipe.

a space of perhaps half an inch between the core and the flask into which molten metal may be poured to form the length of pipe. Before pouring, a top ring, F, is put in place to hold the core and flask solidly in position, and the sides of the flask are clamped so that there may be no slipping or shifting of the parts while the metal is cooling. When the metal is sufficiently cooled, the flask is taken apart and may be used again.

America's advanced position in the industrial world is largely

owing to her taking the lead in iron and steel manufactures. Whether she can maintain the place she has gained, history alone can determine. Manufactures of iron and steel now constitute the third largest item which we export, being exceeded only by cotton and pork. In the year ending June 30, 1903, we exported nearly $97,000,000 worth of iron and steel manufactures, and probably the $100,000,000 mark will be reached before 1905; but only while we continue to build better and cheaper machinery than other nations can such a condition continue.

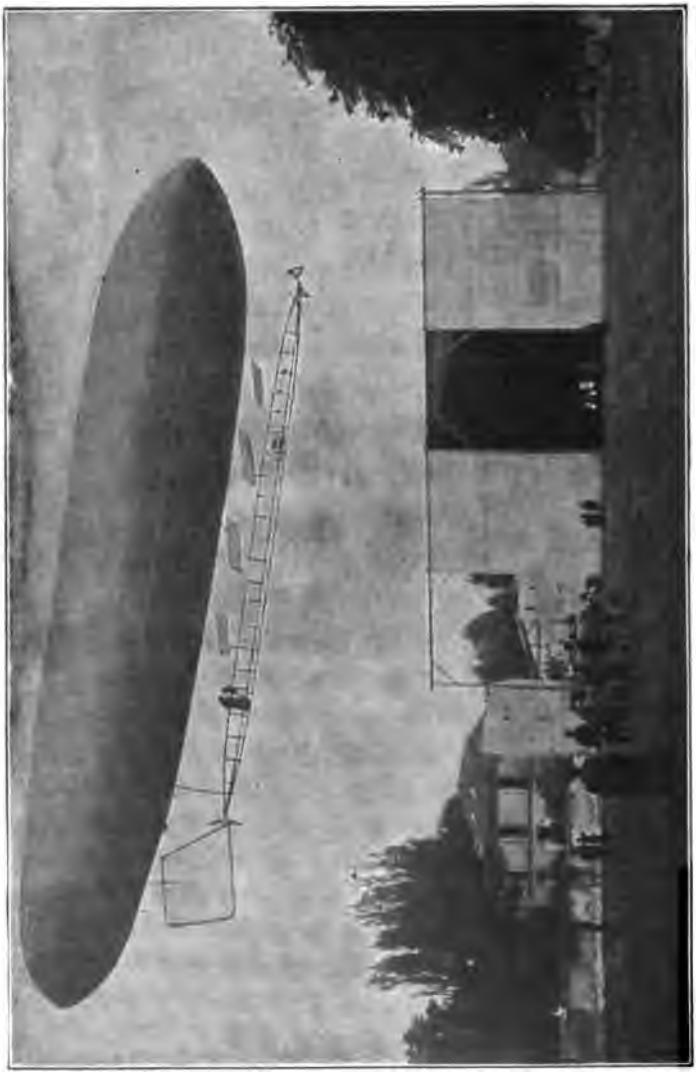
THE CONQUEST OF THE AIR

FIFTY years ago the opinion was prevalent that progress in aeronautics had reached its practical limit, that the balloon was a dangerous toy of no real utility, and that man must leave the navigation of the air to the birds, and be satisfied with locomotive speeds. But even at that date there were a few men who knew better, and who realized that what a bird could do should be done also by man, and that a study of the soaring vulture and the darting hummingbird must yield knowledge that eventually would lead to travelling in the air. There is a sense of incompetency in watching a swift-flying pigeon circling away, and in a brief moment disappearing as a minute speck on a fleeting cloud. To believe that this creature is inherently more capable than man is to deny the superiority of human intelligence over brute sagacity.

Within the last decade experimenters have proved beyond a doubt that flying is not beyond man's ability, and that there are several methods of aerial locomotion, each having some advantages. The study of the nature of the air and of balancing have proved quite as important as the determination of means of support. Investigators in all parts of the world, working on different lines and theories, have added so much to the sum of human knowledge that one may now almost set a date when sky-sailing will be as popular as automobiling is to-day.

The highest authorities on the subject are the most positive and definite in their prophecies as to the future of aerial navigation. Santos Dumont says, " An air-ship the length of the Deutschland, constructed with the proportions of my No. 6, would transport 1000 voyagers of my own weight, with a sufficiently powerful motor and the necessary petroleum, from New York to Havre in two days." Lawrence Hargrave has expressed himself in quite as plain terms, regarding the future as certain of quick development, because of the continued advance of knowledge of the conditions requisite to flight. Hiram Maxim is also an enthusiastic believer in the future of mechanical flight, and so are Octave Chanute, Carl E. Myers, and many others qualified to speak from experience. Professor S. P. Langley is more conservative in his utterances; but it is easy to read between the lines of his carefully worded writings that he too considers that the conquest of the air has practically begun and is near a real accomplishment.

The modern theories that have led to the conviction that air travel will be practical in the near future are based on experiments that prove that the conditions are now so nearly understood that it



The Santos Dumont No. 10.

Courtesy Scientific American.

is simply a matter of perfecting knowledge of known laws, and arranging details of mechanism, to secure practical flying-machines for aerial navigation. While the dirigible balloon has met with the most apparent success up to this time, yet the building and trying of

aeroplane machines probably has added more to man's knowledge as to the conditions of artificial flight.

All the essential features of a successful flying-machine having been worked out by the different investigators, each in his own way proving that such and such things can be done in actual practice, it only remains to put all the good results into one machine, and perfect its weaknesses, and the world will have a practical air-ship. Let us hope that the date of realization will not be delayed by reason of patent disputes and quarrels as to who invented this or that. When the successful air-ship comes, it will not be the work of one brain, but of the hundreds that have studied the problems of flight.

He who would navigate the air must have special regard for the following points:

1. *Supporting power.* For this aeronauts depend on gas-bags, parachutes, and canvas imitations of wings, called aeroplanes.

2. *Ability to balance and maintain equipoise.* To secure this, the weight is adjusted at the lower part of the structure, and four-vaned rudders are employed, also gyrostatic devices. The placing of one aeroplane above another in series has also been found to give stability in the air.

3. *Motive power of sufficiently light weight.* The most satisfactory power found thus far has been the petroleum engine, of the type used in automobiles, but lightened, usually very near to the danger-point of breaking.

When Hiram Maxim's flying-machine in 1894 developed lifting power, and broke itself in its efforts to fly away from the track that held it down, Mr. Maxim said, "Propulsion and lifting are solved; the rest is a mere matter of time." Notwithstanding this strong utterance, the balancing problem, that was then unsolved, remains a serious difficulty. It is much harder than any sort of balancing with which man is familiar, as on the bicycle, or the sailing yacht, or with the kite, and a tumble is apt to mean death to the tumbler. Once the air-ship is afloat, she is in only one medium, and that of great tenuity, and as uncertain and vagarious in its action as it is possible to conceive.

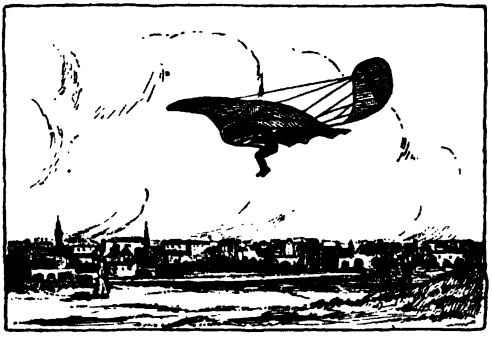
Professor S. P. Langley added much to our knowledge of the uncertainty of aerial conditions in his contribution to science entitled "The Internal Work of the Wind." It was shown that a wind rated at, say, thirty miles an hour proved, under test by a specially accurate wind-gauge of his construction, to fall for short periods to less than half that speed, and then to rise far above it for an instant. In short, the ordinary wind-gauge registers only the average or

mean rate at which the wind blows, whereas in reality it is always inconstant, both in force and direction.

Investigators in the aerial field have approached the subject from different directions. There have been the soarers or gliders, of whom the lamented Lilienthal was the first; then the kite-flyers, of whom Hargrave, Eddy, Lamson, and the experts of the United States Weather Bureau have been in the lead; then the dirigible balloon experimentalists, of whom Dumont in France and Myers in the United States have been at the fore; lastly, the aeroplanists, or users of power-driven sailing-planes, of whom Maxim and Langley have been the undisputed leaders, while the Wright brothers must now be classed with them.

THE SOARERS OR GLIDERS.

Dr. Otto Lilienthal solved the problem of what he termed soaring flight, and died a martyr to his love of science. His gliding machine was a surface equivalent to large broad wings, which he held



Lilienthal's Soaring Apparatus.

at the level of his armpits, and then, running a few steps against the wind from a hill-top, picked up his feet and floated or glided along, supported by the air, in a gradually descending course to the foot of the hill. His longest flight made in this way was 1200 feet, and he often rose to a height of fifty or more feet from the ground, and might have risen higher had he faced stronger winds, for it was demonstrated that the stronger the wind the greater the lifting power of the planes or wings.

Just as Dr. Lilienthal began to feel that he could navigate with some certainty, having made some 2000 glides, and as he was learning to circle a little, on August 11, 1896, he was caught by a gust

of wind, carried up unexpectedly, lost control of the wings and his balance, and fell to the ground fatally injured.

Percy S. Pilcher tried similar experiments with some success, until he too came to his death by an untimely fall. The four views

Sailing.

Preparing for Flight.

Dropping when Going Fast.

Ready.

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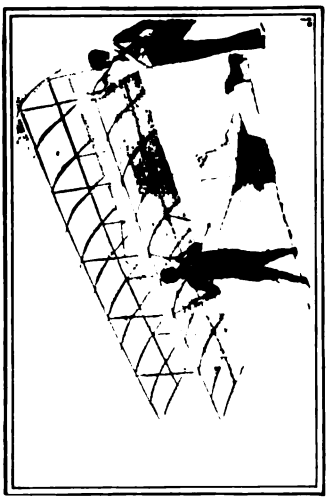
Pilcher's Soaring Machine.

here given of Pilcher's machine show its construction and operation quite clearly.

Several gliding machines were built by Octave Chanute, in an endeavor to improve on Lilienthal's apparatus. Some of these had multiple wings or planes. In these he arranged for the aviator to sit still and maintain the balance by shifting the wings. He very

wisely practised making short glides at low speeds. During 1896 he built and experimented with five different machines, making about a thousand glides from a sand-hill on the edge of Lake Michigan,



Struggling for a Poise.

About to Alight.

A Good Start.

Dropping.

Chanute's Soaring Apparatus.

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about thirty miles from Chicago. His best results were secured with a two-surfaced machine. The hill was so low that he could seldom glide over 300 feet, which distance was covered ordinarily in about twelve seconds. The stop was accomplished just as a bird stops,

by tilting the wings almost at right angles to the direction of the glide, thus using the air as a cushion.

Chanute, Hering and others who assisted him never met with any serious accidents, partly because they were fortunate, and partly because they avoided strong winds, the fastest of their experience being thirty miles an hour. On one occasion, however, when four men were carrying one of the machines, a sudden gust picked it up and conveyed the four to a height of about a hundred feet, which was much more gratifying as an exhibit of lifting power than it was satisfactory to their sense of personal safety. Their combined weight brought the apparatus down very shortly without undue jar to any of them, but it taught a lesson of caution that they could not soon forget.

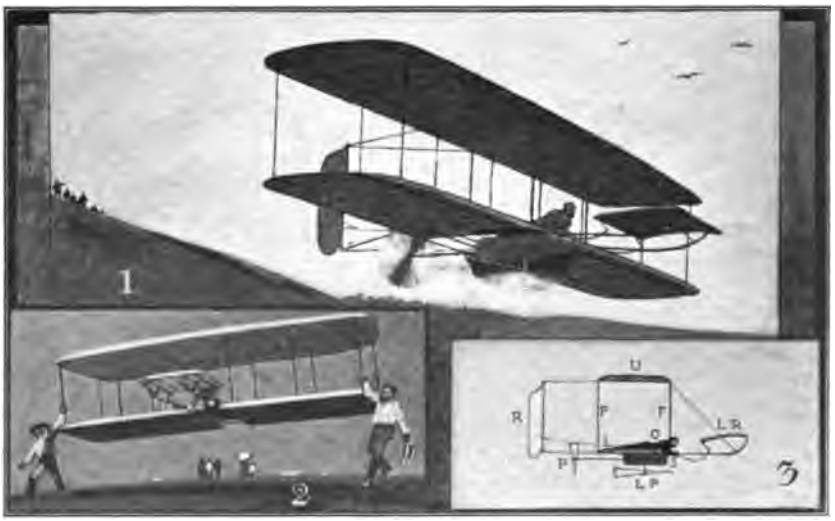
The Whitehead Aeroplane.

One of the latest of the enthusiasts in the soaring field is Gustave Whitehead, of Bridgeport, Connecticut, who has devised several soaring apparatuses, one of which is shown in the illustration. Having studied this system of flight for many years, and taking warning from the fatal accidents of others, Whitehead arranged his experiments so as to do all his soaring close to the ground. When his planes were properly adjusted, an assistant was sent ahead with a light rope, which he pulled after the manner of a kite-string When sufficient speed was attained, the aviator could tilt the planes slightly upward, rising from the ground, and skimming along slightly above the surface. The balancing of the aeroplanes is accomplished by shifting the body much after the fashion of Lilienthal.

In Whitehead's three-deck machine the aeroplanes are located three feet apart, and are a foot in width and sixteen feet long.

The frame is of spruce wood covered with muslin and braced with wires. The four-sided rudder assists the steering. After experimenting with the apparatus and learning that it would carry more than his weight, Mr. Whitehead attached a light motor of twelve-horse power to the lower aeroplane. The propeller driven by the motor was placed in front of the aeroplane, so as to pull instead of pushing. Experiments with this machine were sufficiently satisfactory that another is being built.

All the soarers, gliders, and aeroplanists have been outdone by the Wright brothers, of Dayton, Ohio, who on December 17, 1903, succeeded in making the first successful flight in an aerostat that was not supported by a gas-bag or balloon. On that date Wil-



Wright Brothers' Aerostat.

1. The aerostat in flight, showing position of the motor and propeller. 2. The start. 3. Diagram showing construction and operation of the machine—U, upper surface; R, rudder or movable tail; F F, main uprights of frame; L R, lifting and lowering rudder; L, lower surface; O, operator; P, propeller; L P, lifting and lowering propeller; S, seat of absolute control.

bur Wright flew half a mile, near Kitty Hawk, North Carolina, in the two-decked, motor-driven machine developed by himself and his brother, which is here illustrated. Their successful machine was really an aeroplane, and might be classed under that heading, but, as it grew out of a soaring device, it is included under this head.

The story of their success is best told in Wilbur Wright's own words, as quoted in the *Scientific American:*

"The difficulties which we faced were to be classed in three groups,—(1) those which relate to the construction of the sustaining wings, (2) those relating

to the generation and application of the power required to drive the machine through the air, and (3) those which relate to the balancing and steering of the machine after it is actually in flight.

"My own active interest in aeronautical problems dates back to the death of Lilienthal, in 1896.

"We figured that Lilienthal had in five years' time spent only five hours in the air, yet Lilienthal, with this brief practice, was remarkably successful in meeting the fluctuations and eddies of wind gusts. It seemed feasible to practise by the hour, instead of the second, by building a machine which would be sustained at a speed of eighteen miles an hour and then finding a locality where winds of this velocity were common. With these conditions a rope attached to the machine to keep it from floating back with the wind would give us the same results as if we had a machine driven forward by a motor in a calm.

"We found, according to the accepted Lilienthal tables of air pressure on curved surfaces, that we would need a machine spreading two hundred square feet and that winds of the sort we wished were common along the Atlantic coast. When the winds were low, it was our plan to glide from the sand-hills.

"After much study, we concluded that tails of size were an impediment. Also it seemed reasonable that if the body of the operator could be placed horizontally only one square foot instead of five would be exposed to the wind. Pilcher, Lilienthal, and Chanute had been upright.

"Then the method of control used by Lilienthal, which consisted in shifting the body, did not seem quick or effective enough; so, after long study, we contrived a system consisting of two large surfaces on the Chanute double-decked plan, and a smaller surface placed directly in front at a short distance in such a position that the action of the wind upon it would counterbalance the effect of the travel of the centre pressure on the main surface.

"Thus, changes in the direction and velocity of the wind would have little disturbing effect, and the operator would be required to attend only to the steering of the machine, which was to be effected by the curving of the forward surface, up or down. At that time the lateral equilibrium and the steering to right or left was to be attained by a peculiar torsion of the main surfaces, equivalent to presenting the wings of one end to the wind at a greater angle than the others.

"With these plans we proceeded, in the summer of 1900, to Kitty Hawk, North Carolina, a little settlement located on the strip of land that separates Albemarle Sound from the Atlantic Ocean. Owing to the impossibility of obtaining suitable material for a two hundred square foot machine, we were compelled to make it only one hundred and sixty-five square feet. On the very day that our machine was completed, the wind blew from twenty-five to thirty miles per hour, and we took it out for a trial as a kite.

"We found that while it was supported with a man on it in a twenty-five mile wind the angle was nearer twenty degrees than three; so we turned our attention to measuring the lift and drift of the machine under various loads. The results obtained were most astonishing. It appeared that the total horizontal pull of the machine while sustaining a weight of fifty-two pounds was only 8.5 pounds, which was less than had previously been estimated for the resistance of the head framing alone, fifty per cent. less than Chanute's final estimate.

"On the other hand, it appeared deficient in lifting power. We decided to arrange our machine for the next year so that the depth of curvature of its surfaces could be varied at will and its covering airproofed.

"We then turned our attention to gliding from the top of Kill Devil hill, a sand dune about one hundred feet high. Although landings were made while moving at speeds of more than twenty miles per hour, neither machine nor operator suffered injury. The control of the machine proved even better than we had expected, responding quickly to the slightest motion of the forward rudder. With these glides our experiments for the year 1900 closed.

"When it came to building our machine for 1901 we decided to make it like the previous machine in theory, but we increased the size from 165 square feet to 308 square feet. The curvature of the surfaces was increased to one in twelve. The machine was completed on July 27 and tried in a wind blowing thirteen miles per hour. An attempt to glide was made, and the machine sailed three hundred yards easily.

"After a long series of successful glides and experiments, we returned from Kitty Hawk, and took up experiments in our laboratory to ascertain the amount of pressure on curved surfaces, with a view to approximating the motor power necessary. We knew that one of six horse-power, weighing about one hundred pounds, would be required.

"In August of 1902 we repaired again to Kitty Hawk. Our 1902 pattern, which was practically the culmination of all our experiments, was the same double-decked pattern we had used, and it was used in our last successful trial.

"There were two surfaces, 32 feet from tip to tip, made of straight-grained spruce, for frame, and cloth, airproofed, for covering, with a spread of 305 square feet, a front rudder with a spread of 15 square feet, and a vertical tail of 12 feet square, at that time fixed, but since reduced in size and made mobile. The total weight, to which the motor and gear must now be added, was then 116½ pounds, to which must also be added the weight of the operator, from 150 to 160 pounds.

"On the second day the machine was taken to the big hill and regular gliding was commenced. The wind was somewhat brisk. In one flight the wind struck the machine from the left and began lifting the left wing in a decidedly alarming fashion. I decided to bring the machine to the ground as quickly as possible, but in my confusion forgot the change that had been made in the front rudder and instinctively turned it the wrong way. Almost instantly it reared up, as though bent on a mad attempt to pierce the heavens. But after a moment it seemed to perceive the folly of such an undertaking, and gradually slowed up till it came to a dead stop, with the front pointing skyward.

"By this time I had recovered myself and reversed the rudder to its fullest extent, at the same time climbing upward toward the front, so as to bring my weight to bear on the part that was too high. Under this heroic treatment the machine turned downward and soon began to gather headway again. By the time the ground was reached it was under full control, but as one wing touched first it swung around in landing and came to rest with the wind blowing in from the rear. There was no unusual shock in landing and no damage at all resulted. As a result of this we drew the tips of the wings down some six inches lower than the centre.

"It was now that we fixed on a single movable six-square-foot tail. The majority of the glides had been made in winds approximating twenty miles an hour. One day we worked in a thirty-seven mile an hour wind. We had concluded that we needed at least an eighteen mile an hour wind for gliding. In this wind we found the horse-power consumed to be one and a half, and in a twenty-five mile wind two. At eighteen miles an hour 166 pounds was sustained per horse-power; at a higher speed 125 per horse-power, and we found that at between eighteen and twenty-five miles the ratio of speed and power was about equal, but above or below varied sharply.

"Much time was spent in measuring the winds about us and the flights of our neighbor birds in them. We had many sorts of soaring birds in the vicinity, including bald eagles, hawks, buzzards, and ospreys. Maxim's machine supported to one horse-power twenty-eight pounds, Langley's 1896 machine thirty-one pounds—ours carried 165 pounds.

"Chanute's best degree of gliding descent was seven and a half to eleven degrees. We attained five to seven degrees. If it be desired to fly horizontally through the air by mechanical means, the best angle of incidence would be from five to seven degrees.

"We were now approaching the point of introduction of power into our machine, and in the earlier portion of 1903 made many interesting experiments, culminating in the construction of a motor which we placed under the operator sufficiently to the rear to retain the centre of gravity in its proper position according to our previous designs. A screw fan propeller was geared on a line to the rear, and a second one placed underneath the motor to serve to lift the machine, as the first propeller was meant to drive it.

"The motor was our own gasolene type, and anything new that was introduced had already been suggested by our previous experiments. Early in December we began to look forward to the day of trial. The weather was not propitious, but on Thursday the wind was blowing about twenty-one miles an hour, and I took my place in the machine for a trial from the big hill.

"First, the lifting propeller was started, and facing the wind the machine rose easily and gracefully to the height of about sixty feet, and when the rear propeller began to hum and the lifting propeller to slow down the first flying-machine sailed into the wind and traversed easily a distance of half a mile down the dunes.

"Our experiments are not yet completed, but we feel confident of delivering to the world in no great stretch of time a completely practical flying-machine for every-day use."

THE KITE-FLYERS.

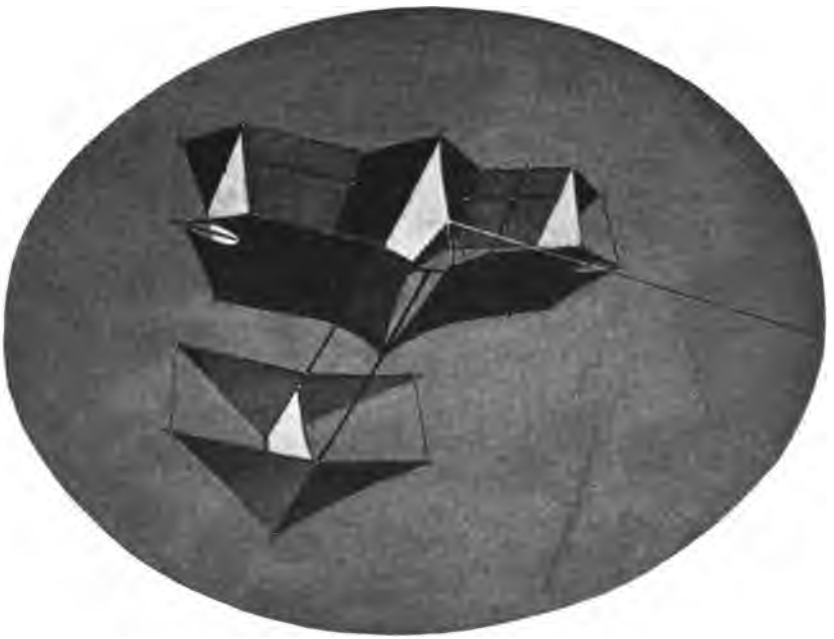
It is uncertain who built the first man-supporting kite. The idea is by no means new. In 1868 M. Biot built one in France and succeeded in raising himself from the ground. It was a crude affair, however, and he kept on experimenting, and in 1880 exhibited a kite without a tail and of great stability, which he patented. M. Dandrieux became interested in the invention and, working with Biot, they brought out in 1887 a great bird-like kite of 27 feet wing-spread, weighing 55 pounds. It proved to have lifting power, but it dropped poor Biot from a considerable height and injured him so that he ceased experimenting. In the same year another Frenchman, named Maillot, lifted a weight of nearly 600 pounds with a kite, and probably could have lifted twice as much if he had put several kites on one cord, and tried them in a good wind.

Lawrence Hargrave designed a great number of kites to test the efficiency of various shapes. He finally settled on the box-kite of oblong shape, that bears his name, as having the most lifting power and steadiness for its weight, and this has not been improved upon since he brought it out more than a dozen years ago. Mr. Hargrave has devoted more than twenty years to the study of aerial science, and added much to the world's knowledge, always making public the results of his investigations.

W. A. Eddy, of Bayonne, New Jersey, improved what was known as the Malay kite, producing a cross-stick tailless kite of good balance, that has been much used, and is generally known as the Eddy kite. When these kites are arranged in tandem,—that is,

a number on the same string, to form a parakite,—they have great lifting power, and can be sent to great heights. Both Eddy and Hargrave box-kites are used together in these parakites, with satisfactory results.

The use of piano-wire instead of cord has lightened kites much more than relieving them of the tail, and the two improvements are responsible for the success met with in flying to great heights, as at Blue Hill, Massachusetts, where A. L. Rotch for years has taken observations regularly with a meteorograph elevated by kites, the instrument occasionally being elevated to two miles or more above the sea level.

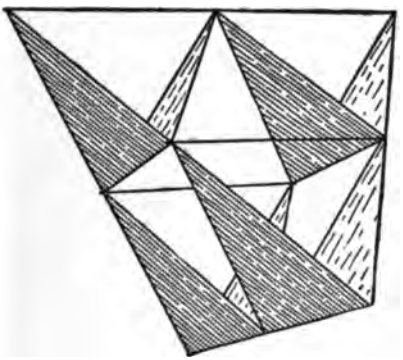


Lamson's Aerocurve Kite.

C. H. Lamson, of Portland, Maine, has taken great interest in man-lifting kites, and has built a number. One of these he calls an aerocurve kite. This has double planes and a double triangular tail, and has proved very stable. The drawing affords a good idea of this machine, which has been imitated by European kite-flyers.

The standard United States Weather Bureau kite is based on Hargrave's, as are all the common and familiar forms of box kites sold as playthings. As made by the Weather Bureau, one contains nearly seventy square feet of supporting surface. It is an

every-day matter at numerous stations to send these kites up from 5000 to 7000 feet, running out from 8000 to over 10,000 feet of wire. In such cases the pull on the wire is commonly from 50 to 100 pounds, from which it is apparent how easy it is to lift a man by stringing a few of these kites on one line. The work of reeling in these kites by hand has become so tedious that a steam-reel has recently been introduced.



Bell's Four-Celled Tetrahedral Kite.

Professor Alexander Graham Bell, electrician and president of the National Geographic Society, has improved on the Hargrave box-kite by producing a triangular form, which he composes of what he calls tetrahedral cells. While the triangular form does not have as large lifting power as the rectangular, yet it braces itself, and he therefore claims that it is much stronger and more reliable. It is capable of being indefinitely duplicated, so that a large kite or flying-machine can be built up by using a great number of these tetrahedral cells. He has built them in a great variety of forms, and his experiments have attracted wide attention, although the records of the kites for flying present nothing remarkable.

THE DIRIGIBLE-BALLOON EXPERIMENTERS.

The dirigible balloon, as now usually constructed, has a cylindrical gas-bag, pointed at the ends, and carries a car with driving and steering apparatus below. The complete structure, with its occupant or occupants, is designed to be very slightly heavier than the volume of air displaced, so that left to itself it would not rise. The gas-bag, sometimes aided by planes or wings, serves as an aeroplane, and is designed to rise when the forward end is slightly elevated and the driving screw rotated by the motor. The balance may be main-

tained by a rope hung below in the form of a wide-spread V, a weight being hung on the rope so that its shifting alters the centre of gravity. Within the hydrogen gas-bag it is customary to place centrally a small bag or envelope, arranged to be distended with air, or relieved of air, according to the condition of the gas-bag. By this means the tendency of the gas-bag to burst under reduced atmospheric pressure or to shrink under increased pressure or from

Carl E. Myers's Sky-Cycle.

leakage, is counterbalanced, and the bag can be kept normally full under all ordinary conditions.

The durability of the balloon has been very much increased within recent years. Carl E. Myers, of Frankfort, New York, who has been building balloons and "sky-cycles" since 1875, and has sent up thousands of persons at fairs and the like, never met with an accident. Count de Castillon de St. Victor made an 800-mile journey in the air, from Paris to Sweden, a few years ago. De la Vaux kept one of his balloons up for thirty hours, while M. Mallet

made a tour of France in the same balloon, landing once a day. In fact, so secure has the balloon become that Mr. Myers makes the assertion that "A modern balloon, properly constructed and carefully inflated, is less dangerous than a railroad, so far as travel is concerned." It is, of course, the descent or landing from a balloon that remains fraught with danger, because the aeronaut cannot with certainty choose his landing-place. *Per contra,* the record of deaths

The Santos Dumont Airship that Circled the Eiffel Tower.

from ballooning accidents from 1875 to 1903 includes twenty-three names. There is no accurate record of ascensions to show the percentage of fatalities.

Santos Dumont's famous balloon No. 6, in which he won the Deutsch prize October 19, 1901, is typical of the dirigible class of vessels, and its dimensions, etc., are therefore given here. In form it was an elongated ellipsoid, coned at the ends, and measuring a little more than 100 feet over all, with a diameter of 16.7 feet. Its capacity was slightly below 22,000 cubic feet. The gasolene motor

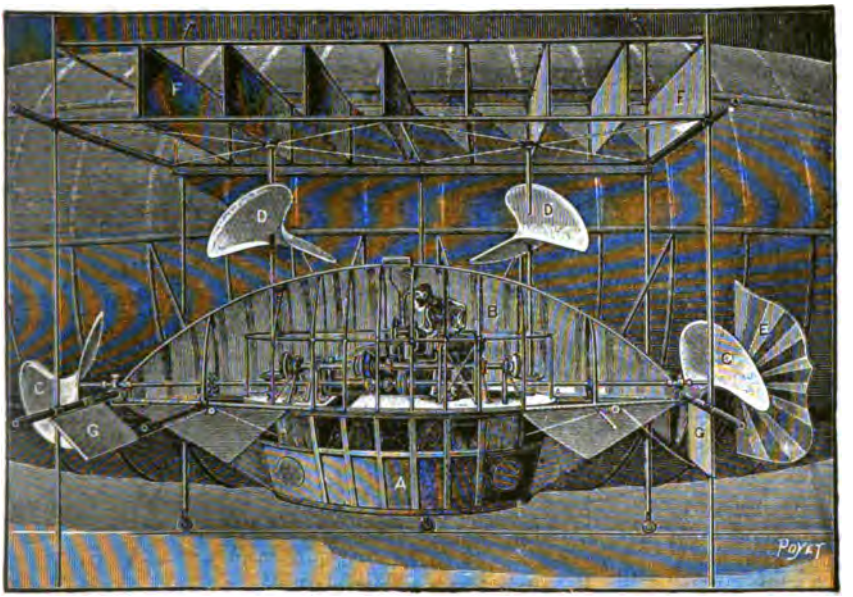
was of twenty horse-power, and served to drive a two-bladed rotating screw-propeller with a spread of thirteen feet. A truss forty-six feet long formed the car, the propeller being located at the forward end, which is now generally preferred to the aft end. This truss or keel was connected with the gas-envelope here and there by steel wires. The envelope weighed 242 pounds, was made of silk, and included 5000 feet of seams. The interior bag or compensating balloon was one-tenth the capacity of the bag proper. This balloon, which replaced M. Dumont's No. 5, destroyed in an accident, was completed in the remarkably short time of twenty days.

Dumont's success has resulted in the construction of a dozen or more very similar dirigible balloons. His No. 10 is longer and slimmer in proportion than most of its predecessors, and has a carrying capacity sufficient for raising ten passengers in the five baskets. Its special feature is the use of four rectangular planes between the gas-bag and the keel, these planes having a total surface of 144 feet, and being designed to shift so as to alter the plane of direction. The 60 horse-power petroleum motor drives the two 12-foot propellers located fore and aft.

Perhaps the most unique of the dirigible balloons was the "catamaran" twin craft built by M. Roze at Colombes, France, and named the Aviator. The gas-bags were in form much like Dumont's, but larger, being 147.6 feet in length. They were connected by several tubes of aluminum and sundry braces. The envelope was of silk, the cones at the ends being of aluminum. In order to maintain an equality of pressure between the two balloons, valves were placed in the tubular connections, this being essential that they might move in the same plane.

Between the twin gas-bags was located a two-decked car, carrying the two 10 horse-power motors and the steering apparatus. Above this car was a very original parachute apparatus, for added safety in descending. It consisted of twelve bands of silk, each 13 by 3 feet, designed to hang horizontally between the gas-bags when the structure was rising, and to spread out horizontally when descending, or at the will of the operator, forming an aeroplane of large supporting surface. The total weight of the machine was 5720 pounds, this being 220 pounds more than the lifting power of the gas-bags. M. Roze held to the opinion that it was desirable to have his machine considerably heavier than the gas would lift, depending on the motive power and air-pressure on the aeroplane surfaces for the rest. In practice, the weight was too great to be overcome, and the trial ascensions were not satisfactory.

Mr. Spencer, an English inventor, has built two machines, his second air-ship, in 1903, being a gas-bag machine 86 feet in length and 21¾ feet in diameter, giving a capacity about twenty per cent. greater than his previous machine. The chief novelty of Spencer's gas-bag is that it is flat at the lower side and is blunter at the forward end than aft. The lifting power is 960 pounds, and the keel is trussed much after the fashion of Santos Dumont's machines. The propeller, or tractor as Spencer calls it, is placed at the forward end of the keel, so that the balloon may be pulled instead of pushed through the air. One of the most sensible features of construction



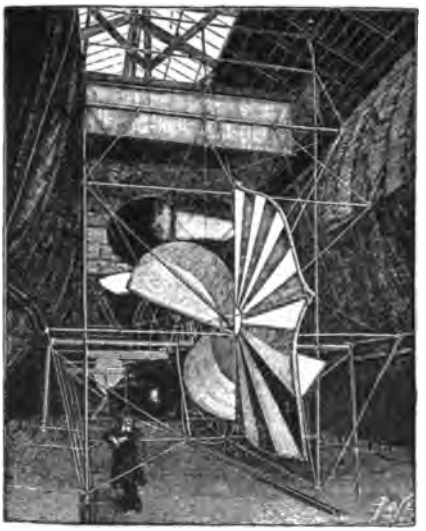
Roze's Aviator, showing Mechanism.

is the placing on the keel of a large water-tank for cooling the motor, and so arranging it that water can be discharged as ballast, which is a considerable improvement over the sand-bag method of reducing gravity. The lower portion of the gas-bag is made in such a fashion that should the balloon burst it becomes a sort of parachute, that is expected to prevent the navigator from being killed in case of serious accident.

Dr. August Greth, of San Francisco, built a dirigible balloon which was tested October 18, 1903, and in which he rose to a height of some 2000 feet and made various evolutions, finally dropping purposely into San Francisco Bay, as being a better landing-place

than he could find elsewhere. This machine was of the usual type and developed nothing particularly new.

While Santos Dumont, Myers, Spencer, and many others have built very satisfactory steerable balloons during recent years, it must not be supposed that they were the first. In 1847 J. M. Partridge built an air-ship, which he called the Pneumadrome, that was very much like those built later, and might have been as successful if he had possessed the light motor and light-weight fabrics which are now obtainable. In this machine he had many of the devices which have been reinvented, several times since, as, for instance, the interior air-chamber, from which the air could be let out as the balloon



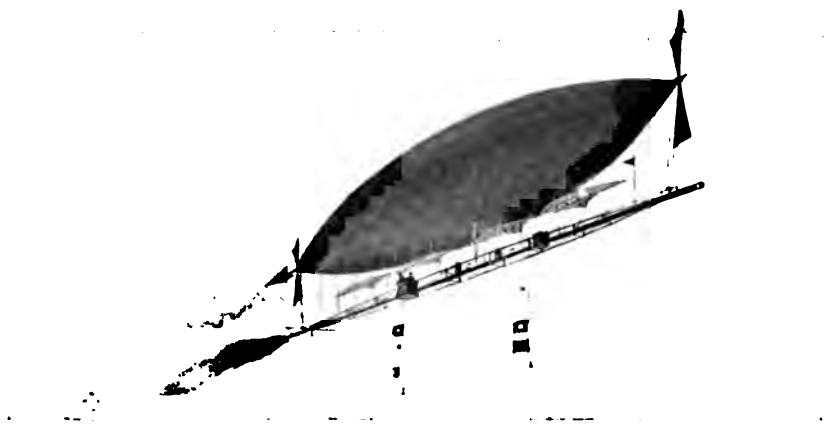
Steering Mechanism of Roze's Aviator.

swelled in high altitudes, thus preventing danger of bursting. His steering devices were also quite similar to those employed at the present day. His fabric was drill canvas, which was treated with rubber to make it air-tight, and which weighed about a pound to the yard. To-day the best balloon silk weighs only one pound for six and a half yards, while stout duck canvas for aeroplanes weighs less than half a pound to the yard.

It seems to the writer that the principal error made to-day in the construction of dirigible balloons is in connecting the propellers with the keel below the balloon. Recently aerial navigators have claimed to secure great improvement by placing the propeller at the forward end of the keel. This is doubtless right enough; but how

much better it would be to have the propeller in line with the centre of the cigar-shaped balloon? And why not have a propeller at each end? If a shaft were run through the centre of the balloon coming out at the ends of the cones, and a propeller attached to both the forward and rear ends, the machine would be under much better control because the pulling or driving power would be in the right place. The car or keel can be regarded only as a drag upon the balloon, and must always serve to impede its progress; and the closer the operating machinery can be brought into axial line with the balloon, the better should be the results.

The desirability of such a construction has been pointed out by several, and the arguments set forth have never been satisfactorily answered by the aviators. Doubtless the strongest reason why this



The Cochrane Dirigible Balloon.

improvement has not been made has been too great regard for the difficulties of connecting such a shaft with driving machinery below; but this difficulty is not so serious, since a pulley and belt connection with a motor on the keel could be constructed to rotate the shaft properly. Very likely the next advance in dirigible balloons will be a construction of this sort. In the accompanying illustration the writer gives his idea of what such a balloon should be. It will be observed that the smoke and fumes of the engine discharge through a tube in the centre of the keel.

Among the numerous believers in aluminum as the metal destined to make aerial navigation a success was Herr Schwarz, who began a vessel with an aluminum gas-bag in 1894. He had the financial support of the German government, and constructed an aerostat

134 feet long, weighing 5720 pounds, at a cost of $50,000. Nearly four years were spent in the building of this machine, which went to destruction six minutes after it first rose from the ground. It demonstrated that a gas-bag could be built of sheet aluminum, and (what ought to have been apparent beforehand) that a slight fall that would not hurt a balloon fabric would injure the metal beyond repair. It was tried in November, 1897, and the aeronaut, who lost control shortly after ascending, had a narrow escape with his life.

Count Zeppelin was another devotee of aluminum; his enormous structure consisted of seventeen small balloons, fixed within a frame of aluminum rods, so that the whole assumed the shape of a tube coned at each end and about 440 feet long by 30 in diameter. It held 108,000 feet of hydrogen gas, and a filling lasted nearly three weeks, costing over $2000. The driving screws and cars were made of aluminum; in fact, aluminum was employed almost in every place where a metal had to be used. The machine made one or two flights, without serious accidents, but proved unwieldy and subject to breakdowns. Efforts to test it were soon given up, after some $250,000 had been expended. More than half of this money was furnished by Zeppelin, who was financially ruined by the experiment, receiving no satisfaction in return, except the name of having built the biggest of the dirigible balloons.

The writer is one of those who do not believe in the use of aluminum in air-ships, for the simple reason that it is heavier for its strength than steel, the idea that its lightness gives it value for aerial structures being wholly an illusion. The wires used as kite-strings in making the record ascensions were of steel, being what is known as piano-wire, and had much greater tensile strength, pound for pound, than aluminum wire. Aluminum is a light but not a strong metal, and, while it has its place in mechanics, just as have copper and brass, yet it ought not to be employed in air-ships where steel will serve the purpose, because a less weight of steel will give the same strength. Why inventors cling to it, when these facts are common knowledge to educated mechanics, is a matter of surprise, and suggests a fatal ignorance on the part of those who use it.

THE AEROPLANE-MACHINE INVENTORS.

The first important aeroplane machine was a three-decked affair built by Stringfellow in 1868, and exhibited at the Crystal Palace in London, where it took a prize of £100. This machine was equipped with an engine and propellers, operating in a space

cut through the central plane. The steam-motor developed 1.3 horse-power, and weighed only twelve pounds with its water-boiler. While it did not fly freely, when suspended from a stout wire it did travel along at a high speed.

But Hiram Maxim and S. P. Langley must ever stand first as persistent experimenters in the aeroplane department of aerial science. Maxim was the first to cause a machine to lift itself from the ground by its own efforts without a gas-bag, and Langley was first to secure a really long flight, developing good balancing powers.

Maxim's Flying Machine.

Maxim surpassed all records of light engine construction by building two 180 horse-power engines weighing about 300 pounds each, or less than two pounds per horse-power. He took a just pride in being photographed while holding one of these powerful engines in his arms. To supply these engines a specially constructed water-tube boiler was employed, weighing with its condenser about 1000 pounds. Because the condenser enabled the same water to be used over and over, about 200 pounds of water was sufficient to run these two powerful engines.

The two great propellers were made of silk mounted on metal frames, the diameter being 17½ feet. These propellers were separately driven by the two engines. All the mechanism was set on a wheeled platform, and above were placed a series of wide-spreading aeroplanes, having a total supporting surface of 4000 feet. The planes were made of double balloon cloth, so that all the flapping would occur in the upper thickness, leaving the lower or supporting surface smooth for the work of lifting. The spread of the planes at the widest point was 126 feet, and the weight of the entire structure, loaded for flight, with three men aboard, was 8000 pounds.

It was on July 31, 1894, that this machine was run over its 1700 feet of track, and, after a few warming-up runs, when the steam was got up to 310 pounds pressure, began to lift itself, after a run of 950 feet, as it attained a speed of about 35 miles an hour. It was prevented from leaving its track by upper rails, and after having run—or rather flown—about 300 feet from the point where it began to bear against the upper rails, the machine was wrecked, owing to the twisting of the wheel-axles by too great an upward pull. At the time of the break-down it was sailing forward at a speed of 36 miles an hour, and lifting about 2000 pounds on the track, while the steam was still about 90 pounds below the pressure at which the engines and boiler could safely use it.

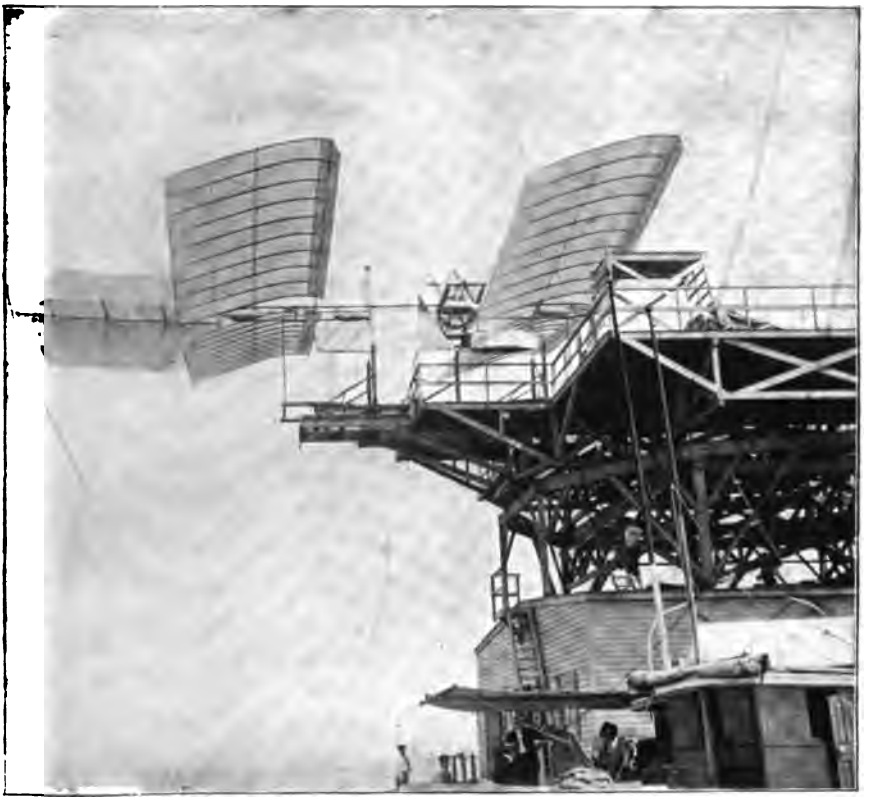
In theory the experiment was eminently successful and encouraging, but it was so costly that Mr. Maxim has not cared to build again, though the showing indicates that with sufficient expenditure he could reach the goal of success with an aeroplane machine.

Professor S. P. Langley tested his first aeroplane machine May 6, 1896, at Quantico, Maryland. This was built on a very much smaller scale than Maxim's, and, while conforming to the principles learned by earlier experimenters, yet in appearance resembled a huge four-winged insect. Its dimensions were based on the employment of a one horse-power steam-engine, being about twelve feet from tip to tip, and, as it weighed 30 pounds, it is noticeable that it was a little heavier for its driving power than Maxim's machine. Its success lay in the fact that it showed good stability or balancing power, and made the longest flight achieved by such a machine at that date. It rose to a height of about 100 feet, sailed in a graceful curve, and when the steam gave out, instead of falling, settled gently and slowly to the surface of the water, after having flown about 4000 feet. This little air-ship attained a speed of 24 miles an hour, and its success gave Professor Langley the courage to build again and try to do better.

The Langley aerodrome of 1903, which had been looked forward to as likely to be successful, proved a bitter disappointment to all concerned, owing to its wrecking at the very start. At the first trial one of the propellers flew off its shaft, causing some breakage which postponed the attempt. A few weeks afterwards the aerodrome was started again, being run along 70 feet of elevated track in order to make a start, from which it should have taken a long flight over the waters of the Potomac. Something was wrong with the balancing, however, and, after hovering an instant in the air, the structure tumbled into the water, and was fished out in a badly wrecked condition.

M. Tatin and Dr. Richet, two French inventors, in 1897, built a machine, on lines very similar to Langley's, about a third larger, with a less efficient engine, but being over-heavy, succeeded in soaring only 460 feet, though they are reported to have attained a speed of 40 miles an hour.

Emile Berliner, the well-known inventor, has given attention at times to the flying problem, and constructed a curious aeroplane



Langley's Aerodrome of 1903.

in 1902. This was a model machine, weighing thirty pounds including ballast. Its frame was of combined aluminum and tin plate, and the length was seven feet. The motive power was furnished at the trial by two sky-rockets, and it travelled about forty feet, then turned backward and tumbled, it is thought owing to incorrect ballasting.

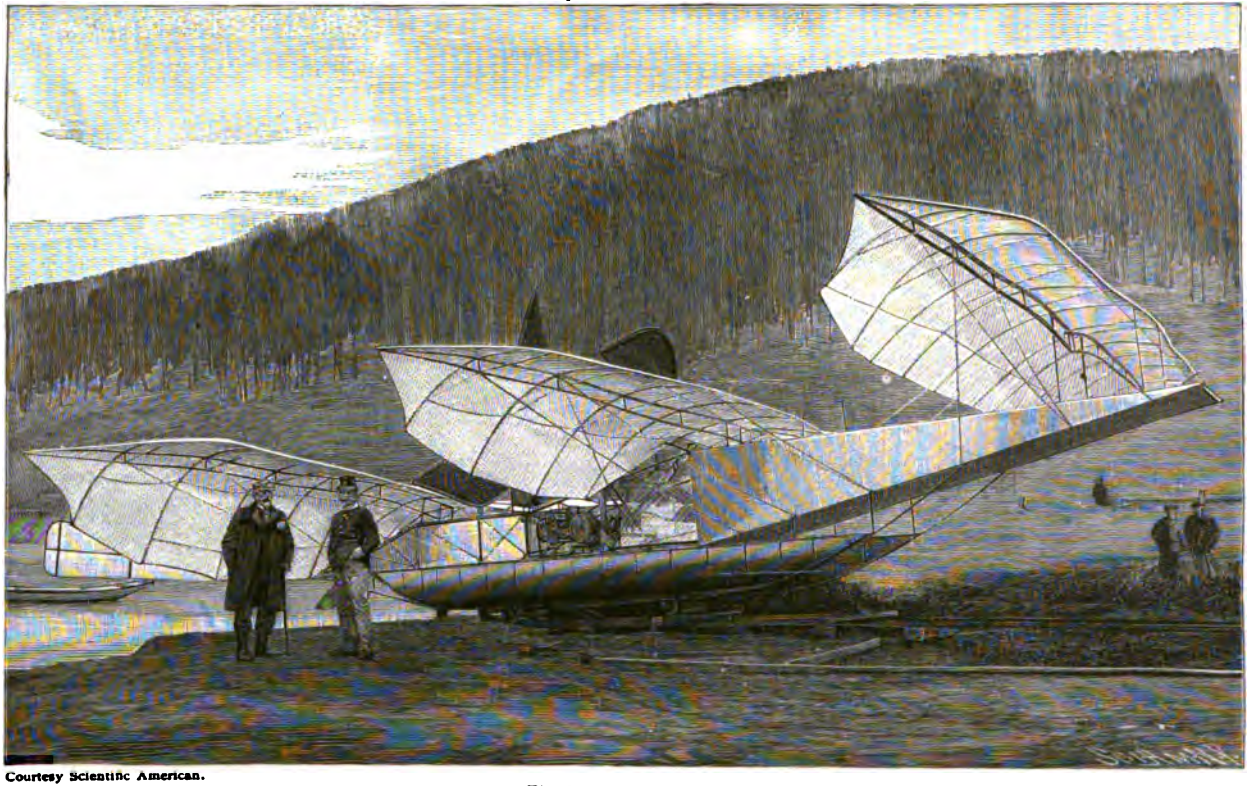
M. Clement Ader, a Parisian, has spent probably nearly $200,000 in investigating the principles of aerial flight. He even went

to Algeria to study the native vultures, which are the largest in the world, sometimes measuring ten feet from tip to tip. He found that they sailed on the air very much as Lilienthal did, giving only a few flaps of the wings at the outset. He built a machine which looked like a gigantic bat, and measured about 50 feet from tip to tip. It was designed to run along on wheels and then rise against the wind. The exact facts of its trial have not been published authoritatively, but it is said to have flown 100 feet, to the satisfaction of its builder. Its weight is given at 1100 pounds, and its engine as of forty horse-power.

The following table of comparison of these machines affords further information. Professor S. P. Langley may be considered as the most successful next to the Wright brothers, from the point of view of having secured the longest flight, 4000 feet, the nearest approach to this by any similar machine being Lilienthal's soar of 1200 feet. Considered as to size of machine and costliness of experiment, Hiram Maxim stands first. For sustaining power, Tatin and Richet take the lead, their machine developing a lift of 55 pounds per horse-power, which seems to have been largely due to the fact that they secured a speed of 40 miles an hour, though only for the very brief flight of 460 feet.

Inventor.	Tip-to-tip Measurement in Feet.	Area of Surface.	Horse-Power.	Sustaining Power per Horse-Power.	Weight.	Pounds per Square Foot.	Per Hour Speed in Miles.	Length of Flight in Feet.
Maxim, 1894	50	4000	363.00	28	8000	2.00	36	300
Langley, 1896	12	70	1.00	30	30	.43	24	4000
Tatin and Richet, 1897. . . .	21	86	1.33	55	72	.83	40	460
Ader, 1897	49	270	40.00	27	1100	4.00	50?	100?

The aeroplane machine of W. Kress, a German inventor, which was tried in 1901, was novel especially in the fact that it was designed to run along on the ice until a speed was reached at which it would fly. The preliminary trials were made on the water, partly because there was no ice at the time and partly to gain experience. Three large kite-like planes were placed crosswise over a keel, and the apparatus sailed majestically on the water, steered exceedingly well, and made some headway against the wind. The motor proved inadequate, however, and improvements were postponed owing to a lack of more funds for advancing the experiment.



Courtesy Scientific American.

The Kress Aeroplane.

This lack of funds has proven disastrous to numerous promising attempts. If a number of the leading students of aerial navigation could be brought to work together in harmony, and be provided with an inexhaustible supply of money for experiments, the day of the perfected air-ship would be much closer than it can be under present conditions, where the men who have both the genius and the desire to win success in this field are hampered by the extreme costliness of experiments.

The flying-machine of G. L. O. Davidson, of Inchmarlo, Scotland, is of the bird type, with wings like a great mechanical condor. He employs the steam-turbine to drive the propellers, which he terms lifters. The steering is accomplished by a fan-tail, designed to restore the machine to a proper angle when the equilibrium is disturbed. The model was built of a length of about six feet, and, when dropped wrong-side up from a great height, righted itself and glided gently to the surface. This experiment is the more noteworthy because the matter of balancing is by far the most difficult of the problems that face the aviator of the twentieth century. Davidson's humble little machine is, therefore, of more value than if this problem had been solved as well in more pretentious air-ships.

Another promising model machine is that of R. J. Hofman, of Berlin. With a weight of only 7.7 pounds he has succeeded in constructing a little air-craft with over 21 square feet of wing surface, a water-tube boiler, and an engine capable of carrying a pressure of 165 pounds of steam. There are two propellers, and when at rest the entire structure is supported by a light frame on four wheels. The propellers are designed to drive it along on a surface until it acquires speed enough to soar upwards; or it may be projected from a height and gather speed by soaring, on the principle of Lilienthal's soaring apparatus.

Because a balloon must always be at the mercy of a strong wind, while an aeroplane or air-ship based on the kite principle can ride against the wind, many pin their faith to aeroplane machines, regarding the balloon experiments as interesting, but not as affording a solution of the problem of aerial navigation. Professor Alexander Graham Bell voices this feeling, writing as follows in the *National Geographic Magazine:*

"I have had the feeling that a properly constructed flying-machine should be capable of being flown as a kite; and, conversely, that a properly constructed kite should be capable of use as a flying-machine when driven by its own propellers. I am not so sure, however, of the truth of the former proposition as I am of the latter.

"Given a kite so shaped as to be suitable for the body of a flying-machine, and so efficient that it will fly well in a good breeze (say twenty miles an hour) when loaded with a weight equivalent to that of a man and engine, then it seems to me that this same kite, provided with an actual engine and man in place of the load, and driven by its own propellers at the rate of twenty miles an hour, should be sustained in calm air as a flying-machine. So far as the pressure of the air is concerned, it is surely immaterial whether the air moves against the kite or the kite against the air."

And here, with regret, the writer leaves the subject of aerial navigation, confident that, even though he be the first to have classed it as an industry, he will not be the last to look upon it as a commercial factor, and fully believing that ere many years have passed flying by machinery will secure as definite a foothold among human institutions as have the steam-yacht and the automobile.

THE EVOLUTION IN VEHICLES AND ROADWAYS

To the bicycle and the automobile we owe the good roads movement in the United States. When the horse had to do all the pulling, men did not care overmuch if the roads were hilly or sandy or otherwise in poor condition; but when they began to ride the wheel, the aches of hill climbing, the jolts of rough roads, and the nuisance of dismounting at sandy spots made every rider an advocate of better roads. The road-making went on even when the bicycle craze began to fail, partly because people had learned that it was a good thing, and more because it has received new stimulus from those who follow automobiling for either pleasure or business.

As roads have improved, and many have enjoyed the thrills of whirling over highways at railroad speeds, the question has arisen in many minds of whether the automobile in time will not rival the railway, or even put it out of business. Sir Henry Norman, editor of *The World's Work,* puts it thus strongly:

"Why should the community pay a huge sum per mile for a special roadway [steel rails] for cars, and a huge generating-station, when self-propelled motor omnibuses of equal speed, comfort, capacity, and economy can use the common road, and, by their ability to be steered around obstacles, not interfere with the rest of the traffic? . . . Few of our leaders of opinion have yet realized that we are on the eve of a more momentous change than that inaugurated by Watt and Stevenson."

A counter view of the situation is taken by Sylvester Stewart, an authority on railway matters, who replied partially as follows in an article in *The Engineering Magazine:*

"That it is the steel rail more than the locomotive that has worked these wondrous changes is shown by the facts that the locomotive at work off of steel rails has accomplished very little, although it has been in actual or attempted use longer than the locomotive on rails, and that railways without locomotives (horse-railways and cable-railways) are able everywhere to carry passengers three to five times as far for a nickel as any vehicle on any other kind of road, even though the vehicles on the common road have their roadway built and maintained for them free by the taxpayers, while the railway company has to maintain not only its track, but, on city lines, the paving of the street between the rails, and to stand the wear of thousands of wagons using its rails, besides paying in many cases a large sum for its franchise.

"As to freight, the average cost of hauling by road locomotives is at least ten cents per ton per mile, but on railways it is only seven mills (on the Pennsylvania Railway one-half cent), and this charge covers the cost of maintenance of the track and interest on the original cost of construction."

"The highest speed (a mile in 46 seconds) made on macadam by a powerful

automobile built especially for racing, with 70 or more horse-power allowed for the propulsion of two men, has been far exceeded by locomotives on rails, hauling trains. How fast would the automobile go on a macadam road if pulling a train of three cars, each as large as itself and filled with passengers, and how much dust would a man breathe in a day on that road, supposing as much traffic upon it as passes over some railways? Locomotives running alone have achieved a speed of 120 miles an hour. Sixty miles per hour is safe on rails; 15 miles is dangerous on macadam, as would soon be realized if the immense traffic on one of our railways were thrown on to a macadam road. . . . .

"Sir Henry speaks of the 'huge cost' of the railway. Considering the large traffic that can be carried on a steel track its cost is small. . . . . As to comparative cost of maintenance of roadway, there are not sufficient data on which to base a conclusion, but it is probable that a dollar's worth of steel will outwear a dollar's worth of macadam. The life of a traction engine is four or five years; the life of a railway locomotive is fifteen to thirty-five years. All roads but steel are hard on heavy engines. . . . .

"As to a 'change greater than that inaugurated by Watt and Stephenson,' they inaugurated the running of motor vehicles on common roads, as well as on rails, for Watt invented the engine, and Stephenson successfully put it on wheels. They built for all roads, but Stephenson showed that the metal road permitted higher speed and lower rates than any other, even when the rails cost fourteen times as much, per degree of durability, as now. For, before the era of cheap steel, iron rails were used, rails which cost more than twice as much per pound as steel rails cost now, yet wore only one-seventh as long."

These writers are quoted here because they represent the extremes of opinion. Sir Henry Norman is all enthusiasm for a new and promising thing. He wrote as he did probably after a fifty-mile spin, in which he visited more places in two hours than he could possibly have done by any other means of travel, and he found the ride invigorating rather than depressing, as is the railway journey. He is over-confident of results, and imagines that everybody will feel about automobiling as he does.

Mr. Stewart, on the other hand, through great familiarity with the details of railroading, sees the enormous difficulties of developing the automobile into a competitor of the railroads, or of changing the tendencies of a so thoroughly established institution as the modern steam railway. Through conservatism, he loses sight of the fact that this is a world of change, and that the things that seem to us most permanent and fixed are sure to fade away sooner or later before new commercial conditions and social evolutions. The records of the past render it extremely probable that railroads, as we know them to-day, will not exist at all in 500 years, but be succeeded by something better suited to future times.

As between automobiles and railroads, the truth, in the view of the writer, lies about half-way between the ideas of Norman the enthusiast and Stewart the conservative. The automobile will eat into the business of railways and trolley companies, and create new

conditions; but it is not going to cause the steel rails to rust for lack of something to carry, or to stop railway dividends, any more than the coming of the railways proved destructive to travel in wagons and carriages drawn by horses on common roads. The history of one innovation sets a good method of forecasting the history of another. The electric, or trolley roads, as they are more commonly but less correctly called, have opened up means of traffic on country roads and suburban highways that were not open to steam railways. They have taken suburban business away from the steam roads, but,

A Touring Auto.

on the other hand, they have become feeders to the long-distance trunk lines. New conditions have developed, and the enormous growth of trolley roads has not checked steam railways in their earnings, even if it has perhaps prevented increase in their mileage.

It is reasonable to expect the same sort of changes as a result of the advent of the automobiles. They will produce good macadam roads where there is moderate population, and asphalt levelled roads, free from steep grades, where the population is crowded. The wealthier classes will reside farther from the cities, or rather will create new outlying suburbs, depending on auto-carriages for

quick transportation. The express business and trucking of the city will fall on the auto-truck, and the horse will become infrequent in the city street. The old-time stage routes will be revived in districts out of the reach of the trolleys, and auto-stages will carry passengers and do a parcel-express business, serving thus as feeders to both trolley and steam roads. The wealthier classes will give less and less patronage to the street cars and to suburban trolley lines, preferring to ride in more exclusive auto-coaches at a higher fare, when not travelling in their own private automobiles.

When it comes to hauling heavy freight any considerable distance, the automobile will not compare with the steam road operated on heavy steel rails, as Mr. Stewart points out correctly; but because man was made to live outdoors, and because the auto is naturally an open vehicle, and men are learning every day that riding in close cars and nerve-racking trolleys is not good for their well-being—for these reasons the use of the automobile for passenger travel over short distances (under a hundred miles) is bound to increase, and that very rapidly, while the taking of vacations by touring in an automobile is going to increase long-distance travel in the same way.

The very proper tendency to legislate the fifty-mile autos off the regular highways, where people drive horses and walk on foot or ride the wheel, will result in the building of special roads, hard, smooth, and level, where speed will be permitted, and where thirty miles an hour will not be dangerous, but will prove inviting as a healthful and pleasant means of travel. Such a highway is already projected between New York and Chicago.

On automobile roads there may be secured the enduring qualities of steel railways by adopting the plan lately introduced on some down-town New York streets for saving the wear on streets by heavy trucking. Two lines of parallel steel beams or tracks are laid in the roadway, at a level with the surface. These steel tracks are a foot wide and half an inch thick, and are designed to take the heavy wear of travel, as well as to afford the smoothest surface and easiest hauling. On the automobile road they would give the needed increase of durability, without confining the vehicles to the rails.

The wear of the automobile on the roadway is really a serious question, to which the American public is not yet aroused, but which is sure to occupy much attention before long, as it is already doing in France. The road officials over there learned several years ago that there was an increased cost for road maintenance wherever the automobile was popular, and in many country districts these charges increased $50 to $70 per mile per annum. The wear and

tear on a road-bed caused by transporting a given axle-load increases steadily with the increase of travel, and a road built of earth for carriage travel at an average of five miles an hour must be given greatly increased resistance to bear the traffic of automobiles of

Courtesy Scientific American.

Steel Trackway in New York.

twice or thrice the weight on the axles and twice or thrice the average speed. The reduced wear in the matter of cutting by the horses' hoofs does not compensate for the destructive action of the swift and heavy auto. The cost of reconstructing roads to enable them permanently to resist the wear of touring automobiles is likely to vary from a few hundreds to a few thousands of dollars per mile all

over the country, an expense which the tax-payers apparently have got to meet. This road-wear can be minimized as far as the autos are concerned by increasing the width of the tires, but that is about all that the builder of automobiles can do to relieve the situation.

Carriage building developed into an art in Europe about the

Carriage Works, Assembling Department.

middle of the seventeenth century, when carriages and coaches were built for the use of royalty and other great personages, and ornamented and decorated in the most expensive manner. The first effort for producing easy-riding qualities came in the leather straps by which the body of the vehicle was supported. Next came iron spring-plates which were used in connection with the leather straps

Carriage Works, Gluing Department.

on the carriages and coaches of both continents before 1800. The C-spring came a little later, and the present form of axle was first used at the dawn of the nineteenth century. Early in the nineteenth century came the elliptic spring, from which period easy riding really dates.

In 1770 there were 59 owners of carriages in New York City,

24 of these being classed as phaetons, 26 as coaches, and 33 as chariots or post-chaises. The first statistics of the industry of carriage and wagon building in the United States were gathered in 1810, and show that the product of that year was valued at nearly $1,500,000. In the ninety years following the volume of business multiplied nearly one hundred times, the total sales in 1900 being $122,000,000.

The buggy, which came into use about 1840, is a distinctively American vehicle; it put the "one-hoss shay" out of business, and has held its own ever since as the most convenient of light vehicles.

There were no less than 7632 establishments building carriages and wagons in the United States in 1900, every State and Territory but two being represented; Pennsylvania held the lead with 872 manufactories, but Ohio, New York, Indiana, Michigan, and Illinois all exceeded Pennsylvania in the value of products manufactured.

In 1872 the leading makers of carriages formed the Carriage Builders' National Association, which held annual conventions, of much benefit to the trade, and which established a school for the instruction and development of good workmen.

The building of automobiles began in France about 1890 and in America about 1895, not as a branch of the carriage industry, as might be supposed, but rather as an adjunct to the bicycle factory or as a new industry. By 1900 there were 109 concerns in the United States manufacturing autos, with an investment of $5,000,000. In 1903 the most reliable estimate showed that the number of factories had been reduced by ten, while the capital invested had increased to $24,000,000. During 1903 the local manufacturers sold about 20,000 machines. In January, 1904, there were reported 160 American manufacturers of complete automobiles, 130 of them making gasolene vehicles. An organization has been established, known as the National Association of Automobile Manufactures.

Gottlieb Daimler, of Cannstadt, Germany, is the father of the modern automobile. It was he who brought out the first motor-bicycle in 1885, and he has taught the world how to build the light motors that have made the auto successful. He did more than any other one man to develop the internal combustion motor, consuming benzine drop by drop. Daimler's motor was early adopted in France and has been copied everywhere. The French and Germans made the automobile a practical road vehicle while it was yet a toy in America. The first American-built machines were crude and unreliable, and it was not until about 1903 that the

machines of American make began to equal the foreign importations. Our makers had been wiser to copy the French models absolutely, instead of trying to develop better, and so thrashing over all the ground that foreign builders had investigated, discarding the impractical, and finally building on the same general lines that the French manufacturers had earlier demonstrated to be correct.

One of the evidences that American manufacturers of automobiles are now at least on a par with French builders is that Barney Oldfield's fifteen-mile record, run in 14.35 on a circular track, in October, 1903, with a Winton machine, is a world's record. With the same machine Henry Ford made another record for America in January, 1904, at Baltimore, Maryland, by covering a mile on a straight-away course of sanded ice in $39^{2}/_{5}$ seconds.

The popularity of the automobile is not altogether owing to its increased speed over the horse. The horseless vehicle is actually easier for the occupant, and subjects him to less jolting. This is shown graphically by a diagram borrowed from *Die Automobile-Welt*. The jagged line represents the degree and char-

Horse-Drawn Vehicle.

Automobile.

Illustrating the Difference in Vibration.

acter of the jolts or vibrations communicated to a horse-drawn vehicle, and the undulating line the jolts to an auto travelling on the same road. The reason for the difference is found partly in the larger and broader tire of the auto, but mainly because of the regular vibration of the motor, which breaks up their regular jolts of the roadway, producing gentle undulations of the carriage that compare with the movement of a boat over a rippling surface of water.

The automobile has so many good qualities aside from those attending a mere pleasure vehicle that it is only a question of time

when it will displace not only the horse, but the trolley in many instances. Given an asphalt road, the auto-bus has many points of superiority over the trolley-car. It costs a little more for power, but the freedom from tracks will largely obviate the blockade nuisance. There may even come to the dwellers in large cities freedom from the domination of street-car companies that are too stingy to run enough cars to furnish seats for all their patrons. A few lines of auto-buses run in competition with the trolleys of Brooklyn, for instance, would be a great boon to a long-suffering public.

The gain of the automobile in speed and durability within a few years is a remarkable triumph of modern machine development. In the French competition of 1895, arranged by James Gordon Bennett and Baron de Neufeldt, for a run from Versailles to Bordeaux and return, a Panhard-Levassor petroleum-motor carriage made 736 miles in 48 hours and 53 minutes, including all stoppages, being an average of 15 miles an hour. This record attracted universal attention, as demonstrating that the automobile was a practical road vehicle. It was made with a little four horse-power motor. Three years later this record looked very small behind that of 23 miles an hour, established over the same course with a six-horse motor-car. After that it was nothing but the breaking of records almost every week. A twelve horse-power car made the Versailles-Bordeaux trip in 1899 in half the time of the 1895 record. In 1901 the record over the same course was at the speed of 53 miles an hour, and in 1902 60 miles an hour was shown as an enduring speed at the Circuit des Ardennes by a seventy horse-power racing auto. Even this last figure has been exceeded in various events, and it looks as though the ultimate speed of the auto would be little less than that of the locomotive, depending largely upon the nature of the track.

A few of the more prominent types of American-made automobiles have been selected for description here. The Locomobile gasolene touring car is a twenty horse-power vehicle, having all the machinery placed on a rectangular steel frame resting on the axles. This enables the furnishing of any style of body, without change of mechanism. The centre of the axles is only seventeen inches from the ground, and, the mechanism being just above this, the centre of gravity is brought very low. The engine is of the front vertical type, governed to run at 900 revolutions per minute, but by operating the throttle the speed can be reduced to 300 revolutions or speeded up to 2000 per minute. The valves are easily accessible, and can be cleaned with a few strokes of the kerosene hand-pump.

A storage battery supplies the spark for igniting the fuel. It has four cells, two being used at a time for starting only, a high-tension spark being obtained from large coils placed on the dash-board. The sparking-plug is so arranged that it will not short-circuit by being fouled with oil. The power-transmission apparatus, connecting the engine with the rear driving-axles, consists of a simple form of sliding gear, mounted on an intermediate shaft, connected by chains to the rear axle. By means of an interlocking system, the gears cannot be changed until the clutch is disengaged from the engine by a foot-pedal. Another foot-pedal disengages the engine and throws in the brake on the differential gear. A hand lever may be used to operate auxiliary brakes on the rear wheel-hubs, and this lever also throws the engine out of gear.

The Oldsmobile runabout is an 800-pound vehicle of four horse-power, designed to carry two persons, with fuel and water for a 100-mile journey over fair roads. It differs from other makes principally in having a flexible framework, technically termed a gear, that permits the wheels to take all irregularities of the road without straining the vehicle or mechanism. The rear, or driving, axle, with the compensating gear in the centre, runs on roller bearings in a casing made of heavy steel tubing, with two heavy oval flanges that screw together to form the casing for the gear. This construction relieves the driving-axle and compensating gear of strains. The rear wheels are keyed fast to the axle, and both front and rear axles are strengthened by trusses. A single-cylinder balanced motor is employed, and there is but one piston, one connecting-rod and crank, and one balance-wheel. The two valves are directly connected, and the simplicity of the mechanism has its advantages. The speed of the motor is increased by means of a foot-lever acting upon a gate-valve opening, that admits more explosive mixture to the igniting chamber, and is farther increased by advancing the spark controlled by the lever for change of lead.

The White touring car is a steam-driven vehicle, whose most noteworthy feature is a safety boiler using superheated steam. This boiler has twelve flat coils, the water being supplied to the top one, and travelling through to the bottom, by which time it is all converted into superheated steam at a temperature of about 800° F. A thermostat serves as a regulator of temperature, this consisting of a copper pipe with a cast-iron rod inside, for actuating a needle valve to maintain uniform temperature. This boiler does not require watching of the water-level, as do ordinary steam-

boilers, because there is no water-level to watch. If the engine ceases to draw the steam that the boiler is making, an ingenious device traps the water in each coil, thus insuring safety and saving fuel. The arrangement is such that the maintenance of a fixed degree of superheat by the device described, and through the adjustment of the heat supply, gives simultaneous regulation of both water, fire and superheat. The White touring car for four

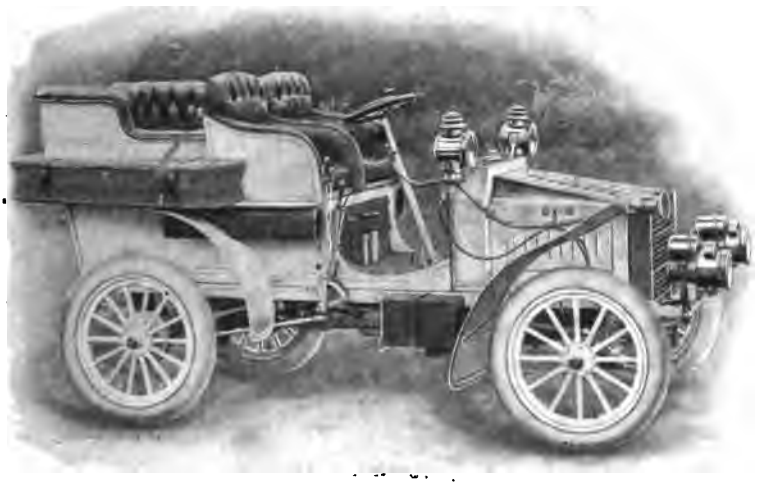
The Locomobile Touring Car.

persons is ten horse-power, and weighs 1600 pounds, having a gasolene capacity of ten gallons, and a water-tank capacity of fifteen gallons.

The twenty horse-power Winton touring car is credited with a 5000-mile trip across the continent of North America in the early summer of 1903. The motor used is a double opposed, water-cooled gasolene engine. A great effort has been made by the makers to reduce friction in the transmission-gear, steel gears being run opposed to bronze, and operated in an oil-tight case. There are two sets of batteries for ignition, so that one may be held in reserve in case of accident. An air governor is employed, operable either by a spring button beneath the chauffeur's right foot

or an air-line valve convenient to his right hand. Pressure on the foot button increases the speed, and releasing it slows down the speed, and thus the use of a set of gears for each variation of speed is avoided. There are but two controlling levers, one operating the hill-climbing and reverse gears, and the other operating the direct driving gear and emergency brake. The chauffeur may be driving at a high rate of speed, and if an emergency arises a single forward stroke of the right arm disconnects the power and applies the emergency brake. The gasolene and water supply are calculated to carry the vehicle over a journey of 175 miles.

Electric automobiles operated by storage battery have been



The White Touring Car.

nearly as popular as the gasolene. Edward H. Sanborn, expert special agent of the United States Census Bureau for the automobile industry, reports that in 1900 a total of 1575 electric automobiles were built, of a value of $2,873,464, out of a total of 4192 of all kinds, valued at $4,899,443. The Electric Vehicle Company, of Hartford, builds a large line of them, including a runabout for two persons, driven by a twenty-cell battery. This vehicle is characterized by three-point body suspension and a low centre of gravity, which combine to give easy riding qualities. There are five speeds forward and backward, the maximum being fifteen miles an hour. There is an electric brake and another mechanically operated. The foot-brake may be locked, which cuts off the cur-

rent, preventing the application of power until released. A Seabright, Victoria, Surrey, tonneau, cabriolet, coupé, brougham, phaeton, bus, hansom, and various other Columbia electric vehicles are made by this company, most of them employing forty-cell bat-

Electric Vehicle Company's Runabout.

teries. The Columbia gasolene touring car has a motor of somewhat unusual design, having four small vertical cylinders, developing twenty-six horse-power.

In 1897 a typical electric-cab service, the first of the kind in America, was inaugurated in New York City, with an equip-

Electric Company's Runabout, with Mechanism Exposed.

ment of twelve hansoms and one surrey, which has since grown into a business requiring about three hundred and fifty vehicles in daily operation, running on the average a total of nearly 6000 cab miles per day. The ordinary motive power for such vehicles

consists of two motors, a storage battery of forty-four cells, and a lever controller by means of which the driver regulates speed, etc. The mileage capacity of a charge of the battery on clean streets is twenty-eight to thirty miles.

There are many heavier and many lighter electric automobiles built than are found in livery service. Some of them are used for dray work, and even for transporting and hoisting safes. For Washington, D. C., a line of electric buses has been built to ply between the hotels and railroad dépôts, while in every city and town light electric runabouts have been a familiar sight for the past three or four years.

An Auto-Van.

A combined gasolene and electric-power omnibus has been put on the market by the Fischer Motor Vehicle Company, after five years of experimenting. The idea has been to secure the good qualities of each system, while avoiding the objectionable features. The system consists of a combined gasolene engine and dynamo, there being one motor for each of the rear wheels, and a small storage battery and controller. The dynamo is free to run at a practically even speed, thus supplying electricity constantly. Under normal conditions the current goes directly from the dynamo through the controller to the motors, but when coasting or slowing up, when little power is needed, the current is automatically taken up by the battery and stored for later use,

while the gasolene engine does what propelling is required. When extra power is needed on a steep grade, the battery supplies it from its store. Thus power is economized, and the benefits of a large power are obtainable at times from a small source. As the gasolene engine runs uniformly instead of irregularly, as in most autos, the gas and air mixtures can be set so as to secure practically perfect combustion, thus reducing the bad-odor nuisance to a minimum. This system is well adapted for auto-trucks and buses.

The general requisites in a gasolene-motor carriage may be summarized as follows:

There should be one horse-power in the engine for every 200 pounds of vehicle ready for travel.

The mechanism should be near the ground, and the motor forward, resting on front-axle springs, guarded from the dust, but receiving good circulation of air for cooling.

A foot-pedal should serve to start the mechanism by a friction-clutch, thus applying the power gradually.

There should be a foot-brake on the main driving shaft, with leverage enough to hold the carriage on a twenty per cent. grade.

A second wheel-brake, that can be set with the hands so as to stay fixed, should be supplied.

Three forward speeds and one reverse speed are necessary, the variable speed-gears being out of use when the highest speed is on, thus avoiding unnecessary noise. The low speed should allow of climbing a twenty per cent. grade of a macadam road.

The steering mechanism should be constructed without lost motion, and allow the carriage to turn in a 22-foot circle.

Cars weighing 800 pounds with full tanks should have tires not less than three inches in diameter.

The pump should be made so that the operator can oil the engine cylinder while running at full speed.

The motor, variable gear, and transmission mechanism are best run in a bath of oil.

The gasolene and water tank should have a capacity that will permit a trip of 125 miles over roads of moderate grades.

The water circulation should permit running at full speed for thirty minutes without bringing the water to boiling point.

The gasolene tank should be so located that a leak will be noticed readily.

The carriage should be capable of a speed of thirteen miles an hour on a six per cent. grade, and six miles per hour on a fifteen per cent. grade.

All the devices employed should be made as " fool-proof" as possible, and be capable of withstanding strains ten times as great as required in ordinary travel.

The mechanism should be so nearly frictionless that a 1000-pound carriage on a smooth level floor, with engine disconnected, can be kept in motion by a pull of twenty pounds.

The consumption of gasolene should not exceed one pound per hour per horse-power.

The auto-truck is steadily gaining in public favor. While the outfit costs more than for two-horse wagons, yet the increased capacity is such that the cost is much reduced. The Adams Express Company compiled figures to show the comparative cost in their work, and found that a two-horse wagon, costing originally

Electric Vehicle Company's Auto-Truck.

$300, involved an annual cost of $1528, while a three-ton auto-truck, costing originally $2500, cost $1825 per annum to maintain. The auto-truck, however, travelled twice as many miles in the year and carried three times the weight of goods, so that, although it required a higher-priced man to operate it, the cost for each trip was only seventy-six cents, as against $1.27 with the two-horse wagon, while the cost per mile was as fifteen to twenty-five in favor of the auto-truck. Comparison with a one-horse wagon was still more favorable to the auto.

The auto-truck has another marked advantage in city use, and that is the saving in space on the roadway. The crowded streets of great cities would be relieved of at least one-third of the crowding by substituting autos for horse-drawn vehicles, and this means fewer jams at crossings and more work accomplishable in a day,

Then a three-ton auto-truck can be stopped by the brake in eight yards, when moving eight miles an hour, while no driver can bring a wagon of that weight to so short a stop. The mechanism of an auto-truck is more reliable than a horse, and does not break down one-third as often as a horse balks or gives out. Also the auto-truck is never tired, and can be worked sixteen or twenty-four hours a day if necessary.

All these considerations are sure to settle the question of heavy haulage in favor of the auto-truck, wherever there are fit roads. Of course, owners of wagons and horses will wait until the former wear out and the latter are incapacitated, but when they have to make changes, most of them will prefer to invest a larger amount and so reduce their cost.

While the gasolene engine has been perhaps the most popular motor for autos, yet it has its limitations, and some of those who run vehicles on heavy roads express a strong preference for steam-power, as having greater flexibility and enabling quicker hill-climbing. The steam-driven machines are heavier, however, and require rather more care and experience in operation. On account of its convenience, the electric auto-carriage has many adherents, though it is not remarkable for its hill-climbing abilities. In the search for a motive engine that will combine all advantages, many experiments have been made, the most successful, outside of those in common use, being the alcohol motor and the ether-vapor generator.

The Bardon alcohol automobile, which has taken several prizes in French races, uses pure alcohol in the carbureter. It works on the atomizer principle, a ball-valve admitting a very small quantity of alcohol, which is vaporized by heated tubes and mixed with air before it goes to the cylinder. The hot air for forming the gas passes in a curved path to the atomizer nozzle, where it draws up the alcohol. The temperature of the mixture is regulated by the degree of heat to which the inrushing air is exposed. This air comes in from holes at the top of the carbureter, where there is a rotating collar for regulating.

Ether has much theoretical advantage over steam for use in a motor, but the danger of fire has prevented its general use. Many experimenters have tried devices for making it sufficiently safe for commercial use. One of the most promising of these is the Desvignes ether generator. Since the boiling point of ether, or point at which it vaporizes, is 97° F., it follows that at a normal temperature of 67° only enough heat is required from the fuel to

raise the ether to 30° as against 145° F. in the case of water, before the point is reached where power is obtainable. Of course, more heat is necessary in either case to develop a pressure of vapor for use, but the calculation is that an ether motor will use only about one-fifth the fuel required in a steam motor for giving out the same amount of energy. In employing ether the difficulty of the designer is to prevent too great heating of the ether, so as to create a dangerous pressure. In the Desvignes generator a feed-expansion regulator is employed, whose object is to limit the

Applying Clay to a Sandy Road.

pressure in the generator. The vapor passes through a series of coils to the pressure-regulator. This contains compressed air which has been provided at the pressure at which it is desired to run the apparatus. By means of a float-valve in the regulator, whenever the pressure in the generator rises above that of the compressed air, the generator discharges its surplus into the regulator, thus maintaining a balance of safety. When the pressure in the generator reduces below the air pressure, the ether is returned by the regulator, so that none is lost. By this very ingenious arrangement the danger of overheating is obviated, and the only danger remaining is that of accident to the mechanism. The experimental machine built, though somewhat crude, developed ten horse-power in the motor, with a weight of only 265 pounds. If

this can be brought into commercial use, it will greatly lighten the total weight of the auto.

The tendency to use the automobile as a modern substitute for the old stage-coach is shown by the touring buses run from Paris to Versailles, and the summer service of wagonettes between New York and Tarrytown, as well as the sight-seeing tours about Greater New York. The fashion having been set, imitations are following in numerous cities that might be cited.

The most startling adaptation of the auto is for fast passenger service on steam railway lines. The Serpollet steam motor and flash boiler, which have been so largely responsible for the success of French automobiles, are to be employed there on cars run on rails, while in England the Napier gasolene motor, which first attracted general attention in the Gordon Bennett races of 1902, is to be applied to individual cars run on a track. This suggests that the improved light motors developed for automobile service may exercise a revolutionary influence on street and passenger railways, especially for suburban service.

The road locomotive, or traction engine, which was in use before the automobile, is a vehicle as much entitled to the latter name as is the auto proper. The development of the auto taught the builders of these traction engines how to build better, and now their machines are sometimes termed automobiles. These road engines were very useful to the British in the South African war, proving their ability to travel over very ordinary roads, and to draw heavy loads at a speed much greater than infantry could travel. One of them, weighing fifteen tons, will draw wagons weighing a total of forty tons, carrying water enough for seventeen miles of travel, and average thirty or forty miles a day, while being able to make from eight to twelve miles an hour when pushed.

Popular Mechanics enthuses as follows in a recent issue over the traction engine and its usefulness:

"Trains that move along dirt roads, or roll over the desert's trackless sands, or in the forests, plowing their way through the underbrush as they pass; trains that ford streams and climb the mountains' sides where railroads never dared to go; trains that turn and stop when and where they please, with rights-of-way as wide as the fields and valleys, the woods and the hills, where they ramble at the will of the engineer. These are the trains hauled by the traction engine, the new, great iron horse of the twentieth century.

"This iron horse has brought with it a new age of commerce. No longer does the mine with its rich deposits of ore lie idle because the railroad does not see fit to build to its site; no longer do the desert's treasures find seclusion in the fiery, desolate bed; fine woods of the remotest trees of the forest are now

A Road in Los Angeles before Oiling.

Same Road in Los Angeles after Oiling.

reached by the woodman's axe; lands far distant from the route of the regular freight and passenger train may now be tilled and made to contribute to the world's commerce; distant quarries are worked, and all sources of commerce are made less dependent upon the railroad and steamship than ever before.

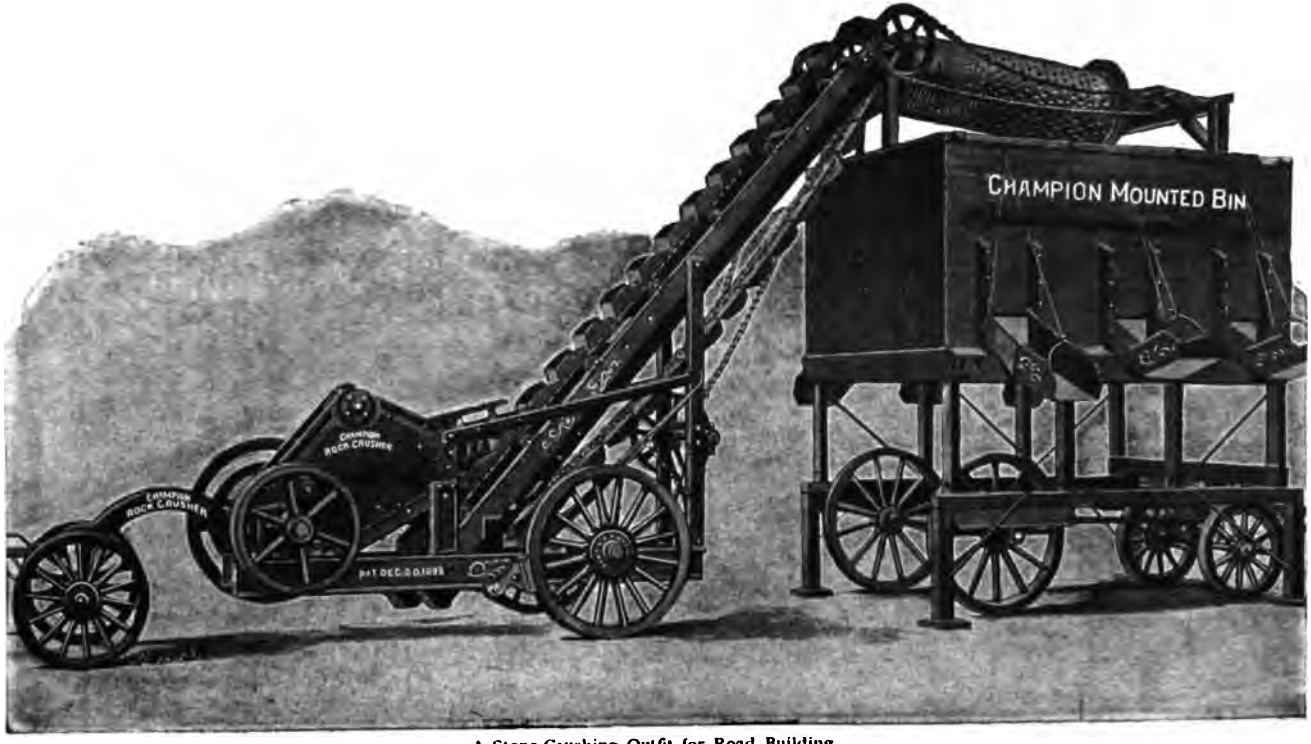
"Many traction engines are in service in many capacities, and, as their utility dawns more clearly into view, they are becoming more numerous and their field is widening many fold. There is now scarcely a commercial pursuit in which the traction engine does not figure. It is displacing the horse, the mule, the tram engine, and the lumberman's 'dinkey.' But while it makes the country's resources less dependent upon the railroads, still it increases the railroad's traffic. For the traction engine rides out into the hitherto unworked, unexplored regions and brings back to the railway station the products of the newly opened fields of commerce for the railroads to haul.

"Great is the traction engine, and each day it is becoming greater. While the world has been a long time inventing the perfected tractor, the machine has at last reached an advanced stage of commercial proficiency; while it is in use in hundreds of different pursuits, it is yet in its infancy."

An automobile bakery is one of the novelties or freak developments of the auto craze. One has been produced in France, with the idea that it will be adopted for army use. M. Schweitzer, the inventor, has provided it with a complete flour-milling apparatus, and, as it runs on its own wheels, as long as the operators can get grain on the route of the army, they can turn out plenty of bread.

As has been remarked earlier in this chapter, the coming of the automobile has aroused attention to the need of more good roads in America. There are not many methods of building a good road, and for general traffic the macadam road takes the lead. To build such a road involves a large amount of labor and expense, but this is restored to the inhabitants of the locality in time saved in travelling and in other ways. A back-country highway when relieved of its steep grades and mud-holes and turned into a modern macadamized road, not only permits of a saving of a third to a half of the time spent in traversing it, but enables heavier loads to be carried with less wear and tear of vehicles, besides inviting more people to locate, increasing the value of land, and hastening the approach of all those conveniences that come to residents of a travelled section of country.

To form a good macadam road, the grades of a section should first be surveyed, and provision made for reducing steep inclines to as low a grade as practicable. There can be no inflexible rule as to grades, but all experience proves that the level road is the cheapest in the long run. Ten per cent. grades mean a greatly reduced speed of travel, and the fewer there are of such the better. Careful attention must be given to the flow of surface



A Stone-Crushing Outfit for Road Building.

water along the route, that it may all be directed where it will not tend to wash away the road.

When these matters have been decided, a gang of laborers is called in to make the cuts and fillings. If only a few feet are to be removed from a hill, the old-fashioned methods of plowing, hand-shovelling, and carting are commonly employed; but if a cut is deep and the soil loose, the steam-shovel may be put to work. If there is much rock, dynamite is employed to break it up so that it can be handled. The earth and rock removed from the cuts serve to build up the hollows.

After the road is cut and filled to the desired grades, a ballasting of rocks or large broken stones is applied to keep the road in shape and prevent its being washed out in severe rain-storms. The more rock used the better, for this is the basis on which the rest of the structure depends for permanency. The macadam road is topped off with broken stone, crowded down by a weighty steam road-roller, and then the road is finished. This last work must be done with care, not only to preserve the evenness of the grade lengthwise of the roadway, but also to secure the slight curvature of the road across its length. A road of sixty feet width should be about a foot higher at the centre than at the gutters, and it is no small trick to lay this curve correctly and carry it out exactly, so that puddles cannot lie in the road. When well made, a macadam road will require very little in the way of annual repairs to keep up its efficiency, but that little labor should be applied promptly after every heavy storm.

A marked improvement in road-rollers is found in a machine recently introduced, which may be used also as a traction engine, simply by changing the wheels. This machine equipped as an engine will haul a load of fifteen tons of stone, and, if this be carried in an automatic stone-separating machine, it may be dropped along the road just where it is wanted, with scarcely any hand labor. As a roller it is just as good as any other, and it can also be used as a stationary engine for driving a stone-crusher, thus furnishing all the power required for breaking, carrying, depositing, and rolling the broken stone of which macadam roads are formed. Another valuable addition to the outfit of the road contractor is the dirt-elevator for use in soft soil. This plows up the earth and carries the loose dirt up on an endless canvas belt delivering into wagons or to the roadway. When the dirt is being deposited on to the road in order to complete the grading, a distributing mechanism is brought into use that will deliver the

loose earth upon any portion of the roadway. A plow is adjusted directly to the shaft of the engine and arranged to deliver its dirt at the lower end of the elevator. Such a dirt-elevating machine will handle about 125 cubic yards of earth per hour in a moderately loose soil, at a cost of about one cent per yard.

Dump-carts have been improved and specially arranged for use in road-grading, having a regulating feed by which broken stone, or dirt, or gravel, or sand can be dropped upon the roadway in any desired thickness. In the case of dirt and sand a sprinkling attachment can be added to keep down the dust. The great demand for crushed stone for improved highways have resulted in the development of portable stone-crushing plants that

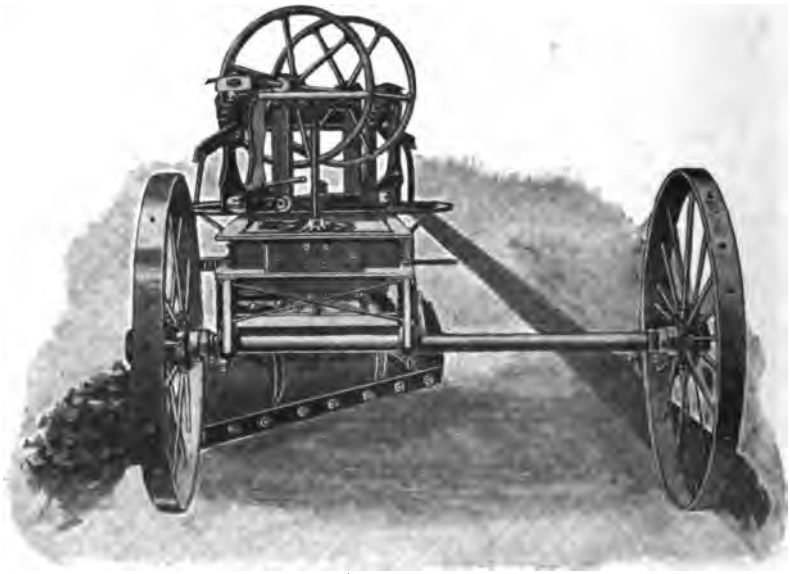
Courtesy Champion Road Machine Company.
Depositing Stone on a Road.

may be located at small expense for breaking up stone on the spot where it is cut out. To reduce handling with such outfits, there are portable bins, with metal discharging gates, in which the stone can be deposited as broken. So well adapted to transportation are these mechanisms, that it is possible to put one at work breaking stone fifteen minutes after the time the whole outfit, consisting of crusher, elevator, screen, and bin, has been set in place.

For soft dirt roads a cheap and satisfactory road-machine has come into common use, having a large steel blade or mould-board, that can be shifted to various angles and used to level and shape the roadway. In the best of these machines, as the steel Champion road-machine here illustrated, the axle is made shift-

ing, and it is possible to set the blade so as to take a cut from the side of the road and push it up into the centre of the highway at one operation. In other machines the mould-board is so made that its curvature can be changed without stopping the machine.

In building mountain roads considerable experience and judgment are necessary in laying them out, so as to secure as easy grades as possible and a permanent roadway. The new roads in mountain regions of the far West are usually built for the purpose of reaching some deposit of mineral. If the ore is of only moderate value, it cannot be hauled over a bad road, full of steep grades, and leave any profit. No team can haul a heavier load



The Champion Road-Making Machine.

than it can handle on the steepest grade of that road; consequently the laying out of such roads is of great importance to the users. The crossing of streams has to be avoided as much as possible, because bridges are expensive, and avoidance of snow-slides is absolutely essential to safety. In cutting into a mountain wall where the roadway is obtained by making a nick or notch in the rocky slope, the cribbing or filling requires to be of the most substantial character if the road is to last; and if the bank is cut down too straight, the action of ice and water is apt to break it down rapidly so that the débris falls into the roadway. In the illustrations of two mountain roads, the Ute pass is much better constructed than the Ouray and Silverton toll-road.

The use of petroleum for reducing the dust nuisance on highways was introduced in California in 1898, being tried on six miles of road in Los Angeles County. The experiment proved a success, and some thirty counties in California are now employing

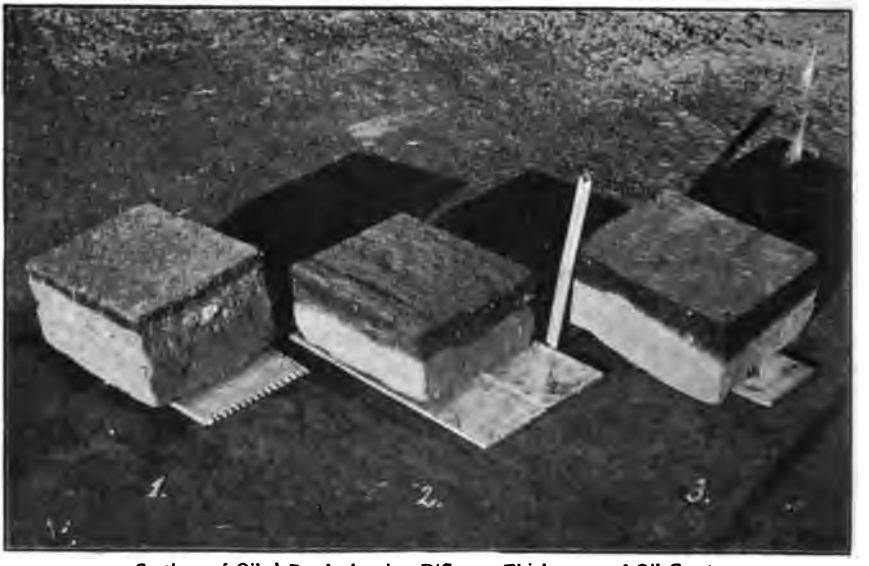
Ute Pass, Colorado.

Ouray and Silverton Toll-Road, Colorado.

this method of dust-laying, while many other States are taking up the system. It was found that the application of oil had many other advantages in addition to reducing the dust, because it tends to form a tough surface or crust that is almost equal to asphalt.

Roads that formerly were full of soft sandy places in dry weather after treatment with oil present a hard, smooth surface at all seasons, upon which teams can draw heavy loads with comparative ease. The oil road has also the advantage that it resists rain-storms. Everybody knows that oil and water will not mix, and in the heaviest rain-storms the water simply rolls off an oiled road, where it cuts and washes other roads.

Oiling gives the road a seal-brown color that is agreeable to the eyes, and prevents that reflection from white sands which is so annoying to people who drive in sunny weather. The illus-



Sections of Oiled Road, showing Different Thicknesses of Oil Crust.

trations give a fair idea of the improvement in a road in Los Angeles County, while the photographs showing blocks of soil removed from oiled roads indicate the depth to which the oil may produce a crust. The road-oiling machine is the equivalent of a watering-cart, oil being used instead of water. Before oiling, a road should be carefully smoothed and shaped, and, after receiving a thorough soaking with oil, should be gone over with a light roller. The best results are obtained when the oil crust is formed to a depth of about three inches. The notion that an oiled road may be a damage in the way of staining materials coming in contact with it is an erroneous one, as the oil tends to stick to the road, and a handkerchief or garment laid on the road for a considerable time will not show any signs of being stained with oil.

In many of the Southern States the laws provide that convicts or prisoners in the jails may be assigned to work on the public roads, and a system has grown up by which the labor of these men is used to improve the roads of the localities. The cost to the State of such convict labor varies from fifteen to sixty cents per day for each man, and the employment of the men out-doors is considered an advantage to the convicts themselves. The sand-clay roads of Richland County, South Carolina, are the product of convict labor, and are not only very cheap but very satisfactory in use. (See illustration, page 135.) Both clay and sand being

Los Angeles, California, Oiled Road after Three Months' Wear.

abundant in that locality, and each tending to make very bad stretches of road, the simple plan was adopted of spreading a top layer of sand over the clay sections, and spreading a layer of clay over the sandy sections. After considerable experimenting, the men in charge learned how to apply and use the sand and clay together so as to avoid too much stickiness in wet weather and too much dust in dry weather. As a result of this work, Richland County has in the past six years improved nearly three hundred miles of her roads, at a cost of about $300 a mile.

Several years ago New York State passed a law providing

for the payment by the State of one-half the cost of new roads to be built under certain regulations, and known as State roads. This was an incentive to towns to accept the provisions of the act, and pay the other half of the expense, thus securing new level macadam roads at a moderate present cash outlay. This law gave great stimulus to road-building in the Empire State, and it has been copied by other States, with results that are sure to be beneficial to the whole country.

A Newly Finished Oil Road.

The prosperity of a country is dependent in a large degree upon its railways and highways, as the means of enabling the people to trade with each other and go about. Unquestionably the auto's influence for good roads marks a new era, whose future can only be guessed at, but which may change our methods of living and doing business as much as the railroads have changed them in the last fifty or seventy-five years. When there is not a square mile of comparatively level territory in the United States without its asphalt roads, this will be a very different country, yet who dares to prophesy that this may not be the case before the opening of the twenty-first century?

THE RACE FOR SUPREMACY ON THE SEAS

THE first boat was undoubtedly a fallen tree that some primitive man dragged to the water and bestrode for a ride. Then came the dugout, the bark canoe, and the coracle; next the row-boat, followed by the sailing vessel, and lastly the steamship. Ever since the first savage burned out his log to make a place to sit in, there has been competition in boats or means of navigation. The end of all that is desirable in sailing craft is not found in the latest cup defender, nor is the last giant steamship of the Atlantic highway the perfection of steam craft. No matter how much one builder outdoes his predecessor or his own previous efforts, within a few years or months along comes something faster, bigger, or better.

Such is progress, not very different on the seas from what it is on land, though the successes of the sea, for some reason, are usually better advertised.

When we reflect what an uncertain waste is the ocean, how the voyager seems lost when out of sight of land, how in storms the waves rise and tower above smoke-stacks and masts, of the dangers from collision, from fire and other sources, it is indeed marvellous that man has established great steel palaces that carry people across the ocean, moving five hundred miles and more a day, with rarely a breath of discomfort or suggestion of accident. These mammoths of the Atlantic, in whose depths are rows of blazing furnaces, into which coal is ceaselessly flung by a small regiment of perspiring men who appear never to tire, are monuments to the industrial progress of the era.

As an American, I wish I could write that the United States is mistress of the seas, and that vessels built on her shores, by her mechanics, and sailing under her flag were to be found on every ocean highway and in every prominent port. Alas, it is not so. Our position as a maritime nation is represented by a single form of success, that of building the fastest ninety-foot racing-yachts. In all other respects Britannia so far outstrips us as a sea power and builder of ships that we are too insignificant for comparison. In 1900 over ninety per cent. of our foreign commerce was carried in foreign bottoms. Seventy-four years previously over ninety per cent. was carried in American vessels. In 1826 foreign

vessels carried seven and a half per cent. of our foreign commerce, valued at a little over twelve millions of dollars; in 1900 they carried over ninety per cent., valued at almost two billions of dollars, an increase of 15,380 per cent.! Could the record be worse?

The foreign trade of the United States and the ship-building industry went overboard during the Civil War, and, though the foreign trade picked up and developed, the work was done thereafter almost wholly in vessels built and owned abroad. There is just one grain of comfort left to us in ship-building. We do build the vessels for our coast and river trade and for traffic on our lakes. In Great Britain, in 1899 (the latest accurate figures I can find for comparison), 567 steel steamships were constructed,

Shamrock III.

with a total tonnage of 1,341,425, and in the same year 123 steel steam-vessels were built in the United States, aggregating 237,397 tons, while in 1903 our figures were 240,107 tons, so that our ship-building ranks as little more than one-sixth of Great Britain's. Of the 123 steel steamers built in the United States in 1899, I cannot learn whether any were built for foreign commerce, but I find in the report of the Commissioners of Navigation that we did build one steel steamer for foreign commerce in 1900, and lately three more have been built that are creditable to our shipyards.

During the decade ending with the last of 1900, a little over twelve million tons of steel steamships were built in the shipyards of the world; a little over six per cent. of these were built

in the United States, and a fraction over 81 per cent. in Great Britain. When wooden vessels are included in the comparison, the merchant navy of the United States makes a better showing, but, as steel vessels are generally replacing wooden ones, there is little satisfaction in this.

Within a few years a new method of launching has come into vogue, being shown in the illustration. The ways are constructed with a slant to one side, and at the proper time the hull is slipped sideways into the water, having a less distance to go than with the end-launch, and taking a position in the water more convenient for subsequent work on the craft.

The New Side System of Launching.

It is in the development of our navy that our chief hope lies in the United States for reviving the trade in our ship-yards. The efforts of the government to bring our navy up to the importance of the country have resulted in the re-equipment of old plants and the establishment of new up-to-date plants where naval vessels of the highest grade can be built. Great Britain has by far the largest navy of the world. France ranks second, Russia third, and the United States and Germany may be said to be tied for fourth place, American statisticians claiming that our navy is the stronger, and Germans calculating to the contrary. Great Britain builds a very fair-sized navy every year, having constructed forty-two new vessels, or rather begun the construction of that many, in 1903. It is confusing to give the figures for a single year, because many

vessels require more than a year for completion, and, as a matter of fact, Great Britain usually has about seventy-five war-vessels in process of construction. The following table shows the condition of the seven leading navies of the world June 1, 1904:

NAVAL VESSELS—BUILT.

Class of Vessel.	Great Britain.	France.	Russia.	Germany.	United States.	Italy.	Japan.
Battle-ships, first class	42	19	13	12	10	12	6
Battle-ships, second class	4	8	4	4	1	..	1
Battle-ships, third class	2	1	1	12	..	5	..
Coast-defense vessels	2	14	13	11	15	..	2
Cruisers, armored	18	9	8	2	2	5	6
Cruisers, protected, first class	21	7	6	1	3	..	..
Cruisers, protected, second class	51	16	5	8	11	5	10
Cruisers, protected, third class	32	17	..	10	2	11	8
Cruisers, unprotected	10	1	3	20	11	..	9
Torpedo-vessels	34	16	9	2	..	14	1
Torpedo-boat destroyers	112	14	48	28	14	11	17
Torpedo-boats	85	247	132	93	27	245	67
Submarine torpedo-boats	5	15	..	..	3	1	..
BUILDING.							
Battle-ships, first class	12 3	7	8	8	9 5	6	.. ..
Battle-ships, second class	..	1	..	..	..	..	..
Coast-defense vessels	..	..	..	..	1	..	..
Cruisers, armored	19 4	13 1	.. ..	3 1	11	1	..
Cruisers, protected, first class	..	..	3	..	..	..	..
Cruisers, protected, second class	2	..	2	..	6	..	2
Cruisers, protected, third class	4 3	.. ..	.. ..	5 2	..	..	1
Scouts	4 4	..	..	..	..	..	..
Torpedo-boat destroyers	19 15	19 4	6	4 6	6	2	2
Torpedo-boats	5	18 25	7	..	4	8	18
Submarine torpedo-boats	4 10	25 18	2	..	5	3	..

For many years the trend of naval construction was towards the most powerful fighting machines—floating forts. Armor two or three feet thick and half a hundred great guns were considered the acme of perfection in battle-ships. But heavy battle-ships are necessarily slow, and during recent years the development has been towards lighter and speedier fighting craft. What does the superiority of the heavy battle-ship count for over the swift cruiser if she cannot steam as fast, and so cannot catch the latter? The advantage is with the heavier vessel only when the lighter craft is blockaded.

While the building of heavy battle-ships has not ceased, at least twice as many armed cruisers are being constructed as of the heavier craft. The cruiser is really nothing but a battle-ship with lighter armor and more speed, and usually less metal-throwing ability.

The greatest novelty in modern battle-ship construction is the superimposed turret, placed both fore and aft on the Kearsarge and Kentucky, two of the most powerful vessels of the United States navy. Critics have found all manner of fault with the de-

Copyright, 1898, by Wm. H. Rau.

First-Class Battle-Ship Kearsarge, showing Double Turrets.

sign, in fact, no naval construction of recent years has been subject to so much criticism; yet the defenders of this construction seem to have met the critics fairly at all points, and the officers and crews of the vessels appear to be satisfied with them. The idea of a turret on a battle-ship is to have a protection or housing for a large gun, that will permit the gun to be turned very nearly to all points of the horizon, and so cover an enemy, whatever his direction. A gun which will shoot to both port and starboard is manifestly as good as two guns, each of which is fixed on one side, with only a small side range. The average turret-gun can

cover two or three times as much of the horizon as a gun set on the side. By having two double turrets these battle-ships can use two guns in each turret, the lower ones being thirteen-inch rifles, and the upper ones eight-inch. As compared with the Oregon, which is of the more usual type of battle-ship, the Kentucky substitutes four eight-inch turret-guns for eight eight-inch guns located on the side ports. There is a gain in firing ability, as just as much shot can be fired on either side, and two guns are gained for ahead or astern fire. The expense and weight and room of the four guns are a clear saving.

Copyright, 1898, by C. H. Graves.

First-Class Battle-Ship Iowa.

In objection to these manifest gains, the critics urge: (1) that the accumulation of weight at the ends of the vessel impairs her seaworthiness; (2) that complication results from crowding in so small a space four ammunition hoists for each double turret, and the mechanism for working them; (3) that firing the four heavy guns simultaneously is not practical, because of the tremendous recoil; (4) that all four guns in a turret might be disabled by a single shot; (5) that it is impossible to direct the four guns of a double turret in different directions at the same time;

(6) that the gunners sighting three of the guns would always be disconcerted by the firing of the fourth.

It would appear to an outsider, from all this, that the Kentucky with her double turrets would make a better showing in a fight than

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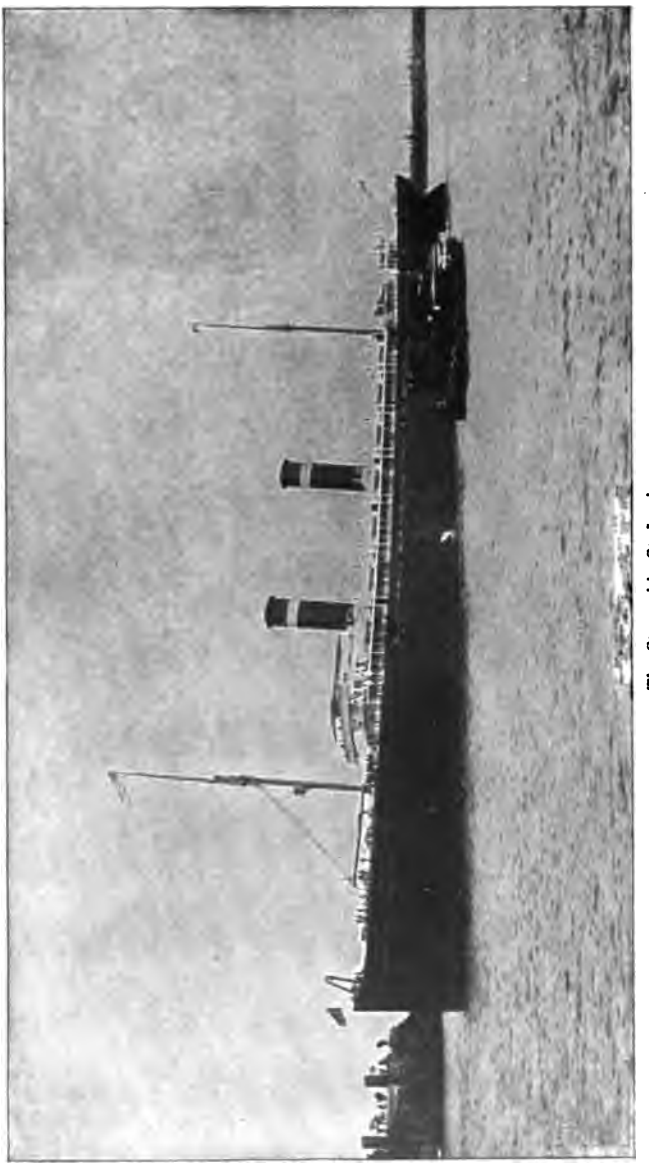
Armored Cruiser New York.

the Oregon, unless a heavy shot disabled a turret, a thing rather unlikely, as the walls of the turret are fifteen inches of steel backed by timbers, and, being curved, a shot would usually strike them

at an angle and glance. After a great deal of discussion the Naval Board of Construction decided to agree to the building of more



The Steamship St. Louis.

vessels with superimposed turrets. Another point in favor of the new construction was gained when the Kearsarge, in July, 1903, broke all records for long-distance battle-ship runs, by steaming

from the Needles to Mount Desert, a distance of 2900 miles, in nine days, four and a quarter hours, including the difference in time. The average per hour was 13.16 knots. This trip was undertaken at the suggestion of President Roosevelt, and demonstrated that this battle-ship could make record speed and yet arrive in fighting trim. It should be stated in this connection that the Illinois and Iowa both hold better records for a short distance than the Kearsarge. Doubtless the reduction in weight of the Kearsarge owing to the use of the turrets had much to do with the record she made. The battle-ship that gets to the fighting place in time for a scrap is certainly worth several that are a few hundred miles away.

The Maine class of battle-ships, which includes the new Maine, the Missouri, and the Ohio, was authorized in 1898. These were designed for a speed of eighteen knots, but on her trial trip, October 21, 1903, the Missouri showed considerably greater speed in a four hours' run. In some respects these are the finest battle-ships afloat. Their displacement is 12,300 tons, length 388 feet, the Krupp armor is eleven inches at the thickest part of the belt, and in the turrets and barbettes twelve inches. The turrets are single, carrying each two twelve-inch guns. There are also sixteen six-inch guns and twenty-four smaller guns, besides two torpedo-tubes. The coal capacity is 2000 tons, stored so as to protect the machinery when the bunkers are full, a plan adopted in all modern war-vessels.

The Georgia class of battle-ships, which includes the Georgia, Nebraska, New Jersey, Rhode Island, and Virginia, authorized by Congress in 1901, forms the largest and heaviest of American battle-ships up to that date. They are 435 feet in length, with a displacement just under 15,000 tons, a beam of 76¼ feet, and a draft of 23½ feet. There are two turrets just forward of the middle, and double turrets fore and aft, giving a total of twelve turret guns. With either bow or stern to a foe, thus presenting a very small mark, shells can be poured in from eight great guns and a number of the six-inch guns. Wood is used very sparingly in the construction, the general opinion of late being that it is a disadvantage in a warship. There is, however, a cellulose belt three feet in thickness all around the sides, so arranged that, if a shot penetrates and lets in the water, the cellulose will swell and fill the hole, thus stopping the leak. The engines develop 19,000 horse-power, and steam is carried at 250 pounds, securing a nineteen-knot speed capacity.

The most powerful battle-ship of the United States navy is the Connecticut, authorized by Congress in 1902 and in process of construction at this writing. This fine vessel, a diagram of which is shown here, taken directly from the specification drawings of the Navy Department, is 450 feet long, 77 feet beam, and of 16,000 tons displacement; her draft is 24½ feet and she is calculated for a speed of eighteen knots.

The defensive armor of the Connecticut consists of a water-line belt eleven inches thick amidships and tapering to four inches at the stem and stern. The casement armor is six inches in thickness and at some points seven inches. The twelve-inch barbettes extend from the protective deck to about four feet above the main deck, and are ten inches thick in front and seven and one-half inches thick in the rear, above the gun-deck. The twelve-inch turrets will have a front plate of twelve inches and rear plates of

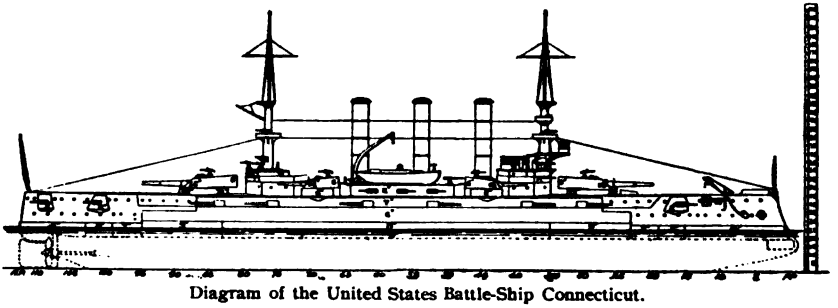


Diagram of the United States Battle-Ship Connecticut.

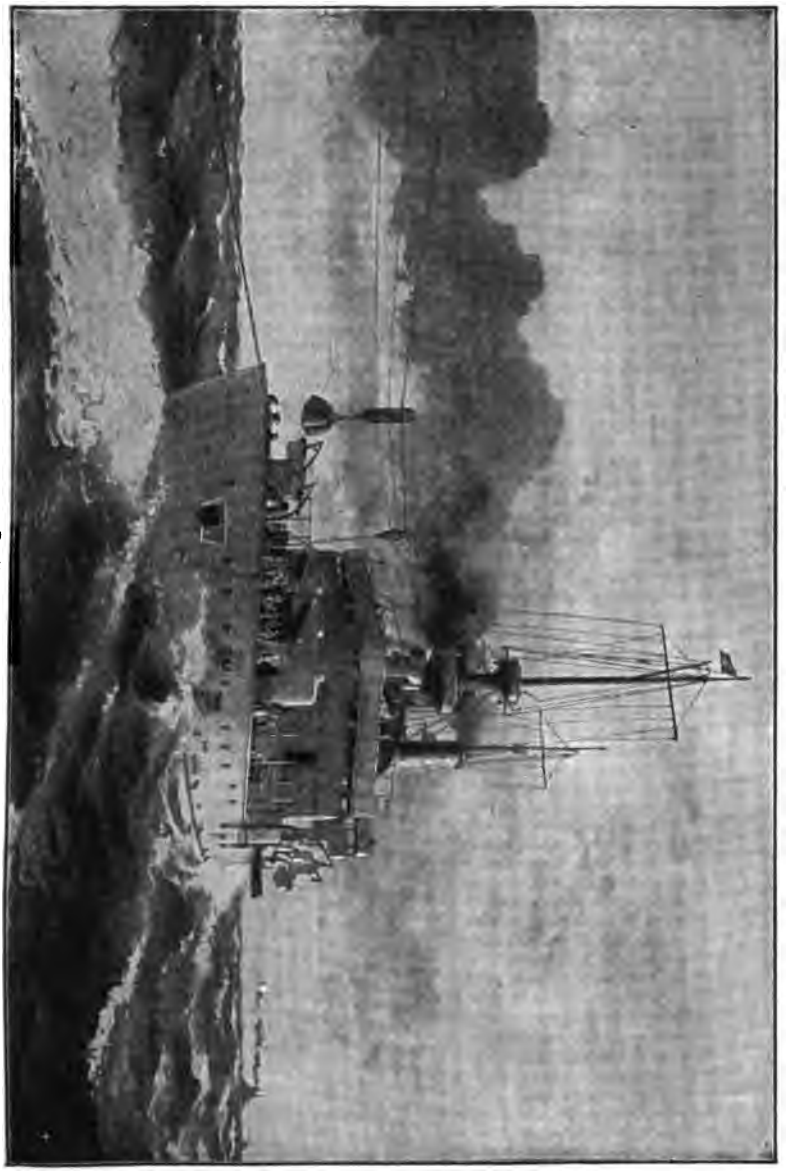
eight inches. The complete protective deck extends from stem to stern, being sloped at the ends and sides.

The armament consists of a main battery of four twelve-inch rifles, mounted in turrets fore and aft, eight eight-inch rifles, and twelve seven-inch rifles, all breech-loaders. The secondary battery consists of twenty three-inch guns, twelve three-pounder semi-automatic guns, six one-pounders, and a number of smaller guns.

The horse-power of the engines is rated at 16,500; they are of the triple-expansion type and the steam is used at a pressure of 250 pounds. Four more battle-ships of the same pattern have been authorized by Congress. The vessel is designed as a flagship, and the arrangement of quarters provides ample accommodations for officers and nearly 800 men. The contract price of construction is $4,212,000.

Of the United States cruisers the Brooklyn is a shining ex-

ample of what such a craft should be. Though carrying defensive armor not much more than half as heavy as a battle-ship, she sus-



Courtesy Lidgerwood Manufacturing Co.

Coaling at Sea.

tained the impact of forty Spanish shells at Santiago without serious injury. She is American-built, having come out of

Cramp's ship-yards at a cost a little under $3,000,000. She is 400 feet long and can steam almost twenty-two knots. Her largest guns are eight eight-inch breech-loading rifles.

But if the Brooklyn is a fine war-vessel, she is outclassed by the six new cruisers of the Maryland class, named the Maryland, California, Colorado, Pennsylvania, South Dakota, and West Virginia. These magnificent ships are over 500 feet long. The protective belt is six inches thick at the thickest portion, and on top of this for a considerable distance are five more inches of armor, so that the protection almost equals that of a battle-ship. While they have no guns larger than eight-inch, there is a very large number of medium-sized guns, that can be fired very rapidly, as witness the following enumeration: four eight-inch rifles, fourteen six-inch rapid-fire guns, eighteen fourteen-pounders, twelve three-pounders, eight one-pounders, two three-inch field-guns, two machine-guns, and six small-caliber pieces for use in boats. The eight-inch guns are mounted in turrets fore and aft, and the majority of the six-inch guns are mounted with such a large arc that they can be fired either dead ahead or dead astern, as well as broadside, in fact four of them swing through arcs of 145 degrees. Thus half or more than half of the battery is available in any direction. There are also two torpedo-tubes, arranged to be fired from stations above.

The ammunition magazines are carefully insulated, to avoid any possible contact with fire, and they are mostly arranged to be kept chilled by refrigerating plants. There is capacity for 500 rounds of ammunition for the eight-inch guns, 2800 rounds for the six-inch, 4500 for the fourteen-pounders, and an increasingly liberal supply for the smaller guns, which is enough, if rightly directed, to send several large navies to the bottom of the sea. Of course, there are water-tight bulkheads, dividing the ships into water compartments, and the doors in these can be shut automatically from a controlling station, so that the effects of even a large breach may be localized and prevented from sinking the ship. These cruisers are designed for speeds of twenty-two knots, which can mostly be exceeded, so that they are practically as fast as any large vessels afloat, being exceeded by only four or five Atlantic liners and the British cruisers of the King Alfred class.

In order to afford a comparison of our cruisers with those of foreign build, the following table has been prepared, in which the Charleston, completed in 1896, of a grade below our Maryland class, is placed against the Esmeralda, the crack cruiser of the Chilean navy, and the Monmouth, of the British navy.

	United States.	Chile.	Great Britain.
	Charleston.	Esmeralda.	Monmouth.
Length on load water-line	424 feet	436 feet	440 feet.
Beam, extreme	66 feet	53 feet	66 feet.
Draft	23 feet 6 inches	20 feet 3 inches	24 feet 6 inches.
Displacement	9700 tons	7000 tons	9800 tons.
Coal supply: normal	650 tons	550 tons	800 tons.
Coal supply: maximum	1500 tons	1350 tons	1690 tons.
Speed	22 knots	23.05 knots	23 knots.
Protection.			
	Charleston.	Esmeralda.	Monmouth.
	Four-inch belt 197 feet long by 7½ feet wide	Six-inch belt 350 by 7	Four inches, tapering to two inches at bow.
	Two-and-a-half inch deck protection to vitals	Two-inch deck	Two protective decks, one-and-a-quarter inches and three-quarters inch.
	Two-inch bulkheads	Six-inch bulkheads	
	Upper and lower casemate armor four inches		
	Four-inch protection to 6-inch guns		Four-inch protection to 6-in. guns.
	Conning-tower and shields five inches	Four-and-a-half inch shields	
	Three-inch hoists	Four-and-a-half inch hoists	
	Four-inch signal tower		
Armament.			
	Fourteen 6-inch	Two 8-inch	Four-inch R. F. guns in turrets.
	Eighteen 3-inch	Sixteen 6-inch	Ten 6-inch R. F. guns in casemates.
	Twelve 3-pounder	Eight 3-inch	Ten 12-pounder R. F. guns.
	Twelve 1 pounder	Nine 6-pounders	Three 3-pounder R. F. guns.
	Two 3-inch field-guns	Two 3-pounders	Eight machine-guns.
	Two Gatlings	Eight Maxims	
	Eight Colts of 0.30		
	Torpedo-tubes, nil	Two submerged. One above water.	

Both the foreign cruisers cited are longer and swifter than the American, and the Chilean is superior in having a torpedo outfit. The Charleston has some minor advantages in protection, especially as to casemate armor; but the most noteworthy difference is in the armament, which exhibits the American practice of securing first all the metal-throwing ability that can be had from a given size and weight of craft, and putting this into as many rapid-fire guns as possible, these proving the most effective in engagement.

At the close of 1901 the United States navy included thirty-five torpedo-boats varying in size and speed from the Gwin, of forty-six tons and twenty-one knots speed, to the Farragut, Goldsborough, and Bailey, all of which are over 250 tons displacement and about thirty knots speed. The Farragut, which is one of the fastest of her class, was built at the Union Iron Works, San Francisco, and is 213 feet on the water-line, with a beam of twenty and one-half feet, and draft of six feet, and has twin screws and triple expansion engines of 5600 horse-power. On her trial trip she made a speed of 30.13 knots per hour. Her armament consists of two long eighteen-inch Whitehead torpedo-tubes and four six-pounder rapid-fire guns.

The torpedo-boat destroyers of the United States are larger

than the torpedo-boats, nine of those recently built being of 420 tons displacement, and designed for speeds of twenty-eight or twenty-nine knots, with horse-power of 8000.

The first vessel to be fitted with the Parsons marine steam-turbine was the Turbinia, which was launched in 1896, and took the record for speed at that time and created a reputation for the steam-turbine which it has held ever since. Her horse-power was 2300 and her recorded speed thirty-four and one-half knots (or thirty-nine and one-half land miles). Other vessels fitted with the steam form of turbine, subject to such improvements as have been developed, are the Viper, which made a speed of about forty-two land miles per hour. This required, however, the enormous horse-power of 12,300. These vessels, together with the Cobra, all belong to the British navy. The latter made a speed of 35.6 knots, or nearly forty-one land miles. Both the Viper and Cobra were lost in 1901. The former ran on a rock in a thick fog; the latter went down on the outer Dowsing Shoal, while making a trip from Tyne to Portsmouth.

The first British passenger vessel to be fitted with the Parsons turbine was the King Edward, built in 1901, which was followed by a companion vessel, Queen Alexandra, built in 1902. As these two boats are of a type that promises to come into considerable use, a description of one will be of interest here. Both of them were built on the Clyde, and the Queen Alexandra is the larger, being 270 feet long, and thirty-two feet beam, and having a draft of eleven and one-half feet. Her speed is about twenty-two knots, and she has proved a little faster than the King Edward. Both these vessels are run regularly on the Clyde in the summer months at twenty or twenty-one knots. There are one high-pressure and two low-pressure turbines, the high-pressure one being in the centre and driving the central propeller, while the two low-pressure turbines each drive two propellers, making a total of five in use. The central propeller is the largest, and makes 900 revolutions on its shaft per minute, while the outer propellers make 1000 revolutions.

Many experts believe that the turbine is destined to succeed the cylinder and piston method of driving the propellers of all classes of steamships. Mr. Parsons contends that the Atlantic liners, as well as large cruisers and battle-ships, would gain more from adopting them than do the small torpedo-boats; as large turbines are cheaper to build in proportion and occupy less space than the older mechanism. For a description of the construction

Courtesy Scientific American.

The Steam-Yacht Arrow at Full Speed.

and operation of steam-turbines, see the chapter entitled " Progress in Power Producers."

The honor has been reserved for an American steam-yacht to beat all speed records on the water, and that, too, over the same route made famous by Robert Fulton, the father of the steamboat. September 6, 1902, Charles R. Flint's steam-yacht Arrow made a nautical mile, which is longer than a land mile, in ninety-two seconds. the speed being the equivalent of a little over forty-four miles per hour. This record is materially in advance of that of other boats of the same character, or of any other sort afloat. The Ellide attained a speed of thirty-nine statute miles an hour, while the Porter's best was thirty-three statute miles, and the Vamoose made over twenty-four statute miles in an hour. All these vessels were built in Nyack, N. Y., upon plans of Charles D. Mosher, who has thereby attained a deserved reputation.

The Arrow was designed for a speed of forty knots, and is 130 feet long on the water-line, with a beam of twelve and one-half feet, and a normal draft amidships of three and one-half feet. Her coal-bunker capacity is seventeen tons and water-tank capacity 1500 gallons. The engines, which are of 4000 horse-power, are of the Mosher patent, and quadruple expansion. The water-tube boilers are also Mosher's patent. Each of these boilers has a heating surface of 5540 square feet, and is designed to sustain a pressure of 444 pounds to the square inch. Their weight with water per square foot of heating surface is six and a third pounds. The cylinders of the engines are designed to work at pressures of 350 and 400 pounds, the piston-speed being 1500 feet.

In making her record trip, the Arrow used picked egg anthracite coal, of a quality so near to perfection that those who watched the race saw scarcely any smoke coming from her stack. The test was remarkable in that the boat did not raise unusual waves nor was it subject to violent vibrations, the twin screws carrying it along with a very uniform motion. The record caused some criticism at the time, owing to the fact that no indicator cards were taken, from which an analysis of the performance of the engines could be made, and because it was not demonstrated that the speed could be maintained for a continuous run of five or six miles. The Arrow, while fitted up as a pleasure-yacht, is capable of being transformed into a torpedo-boat in a very short time. She also can be fitted with additional coal capacity so as to make possible a cruise of 3000 miles.

When repairs are to be made to the hull of a large vessel, she

has to be placed in a dry-dock. These docks are of two kinds: stationary, such as those in which vessels are often constructed, and

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Steamer in Floating Dock.

floating, which are arranged to raise a vessel out of the water. One of each has been selected for illustration here.

Dry-Dock of Detroit Shipbuilding Company.

In 1804, just one hundred years ago, a Colonel A. E. Stevens made a design for a steam-vessel to be driven by twin propeller-

screws, but never completed his device, and the value of the propeller was not demonstrated until about 1840, while the twin propellers have only come into use in recent years on the great Atlantic liners. The race for the record between New York and London has been keen for over sixty years, and there has been a long line of steamboats, each distinguished in its day as the Queen of the Atlantic. From the time of the Great Western, whose trips in 1838 created interest in both continents, the Great Eastern, that Leviathan of the deep blue sea, built in 1858, more than thirty years before a demand for such a vessel—from these times on, there have been continuous efforts on the part of the steamship companies competing for the passenger trade between Europe and America to outdo each other.

The New Yorker, who opens a letter on a Saturday and finds it dated from London the Saturday before, probably forgets that in 1800 the time of travel for such a letter was a question of weeks and not of days. The present transatlantic mail service, made possible by the fast steamships, brings the new resident of America into closer touch with his relatives in the old country than were his forefathers when separated by a distance of a few hundred miles. We now receive our foreign newspapers and magazines before the pith and point of their articles are lost by the lapse of time, and the English, German, and French reader of American periodicals is able to keep well informed regarding our progress on this side of the great pond.

The following table affords a rough idea of the development of Atlantic liners in size and speed:

PROGRESS IN SIZE.

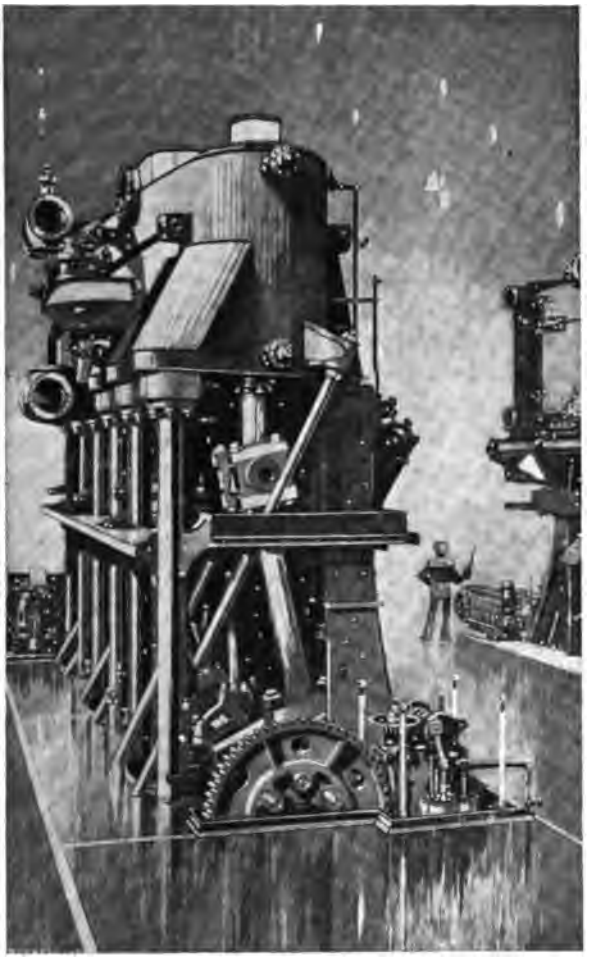
1838. Great Western first to exceed 200 feet in length.
1845. Great Britain first to exceed 300 feet in length.
1858. Great Eastern 680 feet in length, but not an Atlantic liner.
1871. Oceanic (I) first to exceed 400 feet in length.
1881. Servia first to exceed 500 feet in length.
1893. Campania first to exceed 600 feet in length.
1899. Oceanic (II) first to exceed 700 feet in length.
1901. Celtic 700 feet in length.
1903. Kaiser Wilhelm II. 706½ feet in length.
1904. Baltic 726 feet in length.

REDUCTION IN TIME.

1862. Scotia, first to cross in less than 9 days.
1869. City of Brussels, first to cross in less than 8 days.
1874. Germanic, first to cross in less than 7½ days.
1882. Alaska, first to cross in less than 7 days.
1884. Oregon, first to cross in less than 6½ days.

1885. Etruria, first to cross in less than 6¼ days.
1889. City of Paris, first to cross in less than 6 days.
1891. Teutonic, first to cross in less than 5¾ days.
1894. Campania, first to cross in less than 5½ days.
1904. Lucania, first to cross in 5 days, 7 hours, 23 minutes.

In 1888 there was brought out the largest vessel up to that time (excepting the Great Eastern, being the Paris, of 13,000 tons dis-



A 16,000 Horse-Power Marine Engine.

placement and 560 feet over all. Two years later there appeared the Teutonic, which was twenty-five feet longer, though of less beam and displacement. Both these fine vessels developed permanent speeds of twenty knots an hour, which has been only

slightly exceeded by later candidates for public favor. During 1893 and 1894 the Cunard line brought out the twins Lucania and Campania, each of them 635 feet in length and developing a speed of twenty-two knots. For many months these boats took turns in reducing the record in both directions across the Atlantic, bringing the time to less than five days, eight hours, a speed which has not been exceeded by the larger craft built since. The American line constructed in 1895 the St. Louis and St. Paul, which are some 60 feet shorter than the Campania and of about three-quarters the displacement. Their speed, however, is only slightly less, being commonly twenty-one knots. It is the German lines that have shown such tremendous energy in developing both the biggest and perhaps the fastest ocean steamers, having outbuilt the Great Eastern in both length and draft some years ago. As their route is longer than that of the London-New York boats, there is no comparison practicable as to transatlantic time. In 1898 the Kaiser Wilhelm der Grosse was launched, she having a length of 648½ feet and a tonnage of almost 22,000. This great vessel established a speed of twenty-three knots. The next great boat built by the German line was the Deutschland, brought out in 1900 and having a length of 684 feet, with a displacement of 23,620 tons. Her speed proved to be a little better than that of the Kaiser Wilhelm, and she is rated at about 23¼ knots, as are also the Kronprinz Wilhelm and the Kaiser Wilhelm II. These last-named measure respectively 663 and 706½ feet in length. In connection with these record-breakers there should be mentioned the Oceanic, built in 1899, and 704 feet long, and the Cedric, built in 1902, and 700 feet in length. Neither of these boats is intended to be of great speed, although the Oceanic makes 20.7 knots, which would have been considered fast a few years earlier. The Cedric, which was until recently by far the largest vessel afloat, though a little shorter than the Kaiser Wilhelm II., exceeds her in displacement by nearly 12,000 tons, having not only a greater beam but the tremendous draft of 36½ feet. As her engines are scarcely a third the horse-power of the Kaiser Wilhelm II., her speed of sixteen knots is very creditable. It is interesting to compare this gigantic freighter with the Great Eastern, her prototype of forty-six years earlier. The Cedric is eight feet the longer and eight feet less in width, of eleven feet greater draft and nearly 11,000 tons greater displacement, while the Cedric's speed is four knots faster than that of the Great Eastern.

A description of the Kaiser Wilhelm II. will answer generally

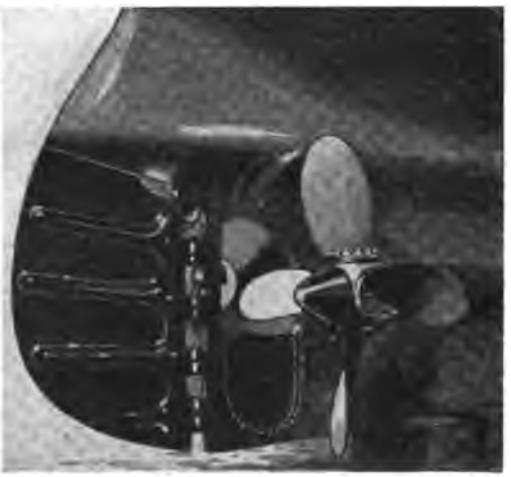
for all the great vessels of her class. If placed on Broadway, New York, she would not touch the curb on either side, but in length would cover slightly more than three blocks—that is to say, she would be visible from four side streets. Her deck would permit passengers to look into the sixth-story windows, and she would furnish as great interior accommodation as the biggest sky-scraper on this thoroughfare noted for its steel business towers. Her passenger capacity is 775 first-class, 343 second-class, and 770 third-class. The crew consists of 48 engineers and greasers, 229 stokers and trimmers, 170 stewards and waiters, besides 61 cooks and 46 sailors. The last figure is almost humorous, showing that these floating palaces have nearly dispensed with the old-time

Crank-Shafts of Ocean Steamship, made by Bethlehem Steel Company.

sailor from their list of necessities. The first-class dining-room is the largest afloat, seating 550 people. The enormous horse-power, 40,000, required to drive this great vessel, is obtained at considerable sacrifice of space for boilers and engines. In order to keep down the size of the engines, four of them were constructed, each having four cylinders for quadruple expansion. Two engines are arranged to drive each of the great bronze propellers, which are nearly twenty-three feet in diameter. Some idea of the great strength of the machinery may be gathered from the statement that, although the steel used is of the very highest grade of strength, one complete crank for one pair of engines weighs 288,000 pounds, while the propeller shafts weigh 160,000 pounds

each. In casting one of these tremendous shafts there was involved the pouring of metal simultaneously heated in 1768 crucibles, and, as the pouring out had to be done in about half an hour, it will be seen that the work was no easy task.

To make steam for these four great engines nineteen separate boilers are required, twelve being double-ended. The coal consumed is over 600 tons a day, and the total heating surface is over two and one-half acres. Notwithstanding the enormous size and great number of these boilers, and the dimensions of the engines, the steam has to be used at a pressure of 225 pounds to the square inch in order to secure the necessary speed.



Rudder and Propellers of Ocean Steamship.

The provisioning of one of these great liners for a six-day trip across the Atlantic is a job equivalent to that undertaken by Noah in the days of the Ark. The stock usually includes from twenty to twenty-five thousand pounds of fresh meat, twelve to fifteen thousand pounds of salt beef and mutton, twenty-five thousand pounds of ham, thirteen hundred pounds of bacon, and five hundred pounds of sausage, together with five thousand pounds of poultry. The vegetables total up to eighty-five thousand pounds, of which sixty thousand pounds are potatoes, while the eggs number twenty-five thousand. Some thirty thousand pounds of the staff of life supply the demand for bread on a voyage, and there should also be mentioned some twenty-five hundred pounds of fish, thirty-eight thousand pounds of fruits, and nearly two thousand gallons of milk. The drinkables of a stronger character than milk

figure up to about five thousand bottles of wine and liquors and three thousand gallons of beer. The necessity for carrying ice is usually obviated by the use of refrigerating machines.

The White Star line's new steamship, the Baltic, which was launched about the close of 1903, is the largest vessel afloat, and in many respects the finest, though having no pretensions to great speed. She is 726 feet in length, of 75 feet beam, 49 feet deep, and has a gross tonnage of 24,000; the cargo capacity is 28,000 tons, and the displacement when loaded 40,000 tons. This vessel is similar to the Cedric in her general design, having a great number of decks and large accommodation for passengers, of whom 3000 can be carried, in addition to the crew of 350 men. She has, according to the *Marine Review,* "a continuous shade-deck running fore and aft, with three tiers of deck-houses and two promenade-decks above. On the upper promenade-deck is the first-class smoking-room and library, and the two houses below contain the deck state-rooms. The first-class dining-saloon is on the upper deck, and all the first-class accommodation is amidships. Immediately abaft the first-class is the second-class accommodation, and also a comfortable smoking-room and library for this class. The third-class passengers are provided for abaft the second-class, and to a limited extent also at the fore end of the vessel. A great feature in this accommodation is the large number of state-rooms of two, three, and four berths, and the commodious and comfortable dining-rooms."

The engines of the Baltic are of the quadruple-expansion type and about 13,000 horse-power, which should give a speed of 16½ knots. The advent of such vessels as the Baltic, Cedric, and Celtic, all of which are designed for room and comfort rather than as speed-record breakers, suggests a new line of development in ocean steamships, and that perhaps the ocean vessels of the future will pay more attention to the comfort of their passengers than to a reduction of the time consumed crossing the Atlantic.

The modern ocean steamers are as safe as dwellings on shore, being built with numerous air-tight compartments and double bottoms, so that it would be possible to damage the hull of one to the length of a hundred feet and yet there would be no danger of sinking. The great length of these boats prevents the pitching that is so conducive to sea-sickness in smaller vessels. The vibration is also reduced with twin screws and an increased number of cranks arranged on the Schlick system. In addition to beautiful drawing-rooms, smoking-rooms, libraries, bath-rooms,

and promenade-decks, there is always a complete drug-store, printing-office, barber-shop, stationery-store, and all other minor conveniences to which people of means are accustomed.

The question is not infrequently asked as to whether this building of steamships of phenomenal speed is going to stop. The best vessel we now have crosses the Atlantic in a little over five days, measuring the distance from the most extreme points of land. The *Scientific American* a few years since made an interesting calculation, to demonstrate what was necessary in order to produce a four-day boat for transatlantic travel, having the enduring speed of thirty knots an hour. The reason why we can build yachts for a thirty-knot speed, while we have not yet succeeded in building better than twenty-four knots in the larger steamers, is that we have not given up in the large steamers the requisite amount of space for boilers and carrying coal. Probably the thirty-knot vessel capable of crossing in four days is about the limit of possibility with methods now known, as the above authority figures that the vessel would require to be 930 feet long and of 110,000 horse-power,—that is, it would have to have nearly three times as much engine and boiler and coal capacity as the Kaiser Wilhelm II. There would be a necessary reduction in the amount of space available for passengers, crew, and baggage, and the amount of machinery would be so great that the noise and vibration could not help but be considerably more annoying to the passengers than they are in the present steamships. While such a construction is possible mechanically, it does not look as if it would be commercially profitable to build a boat on these lines.

The Deutschland, the Kaiser Wilhelm II., and other boats of that class cost about $7,000,000 each for construction, and the building of a boat at a cost of probably $20,000,000, to save a day or a day and a quarter in transit, would not be likely to prove profitable, unless there were other gains such as increased carrying capacity or more agreeable surroundings for passengers. The turbine engine is looked upon by many as likely to reduce the time across the Atlantic, and very possibly it will cut off a few hours. But it is probable that the public will have to wait for any considerable increase in ocean steamers until some revolutionary invention makes it possible to construct a boat that will make the trip in the required time without sacrificing the comfort of the passengers or ruining the steamship companies with coal bills.

That the time will come when America will build as large ships and as many of them as any other nation is firmly believed by the

writer. An indication of what can be done in our yards is shown in the steamers Kroonland and Finland, of the International Steamship Company, these being each of about 13,000 tons and 580 feet in length. They were built by the Cramps, and are of steel

The Minnesota—Largest American-built Steamship.

throughout. But the largest steamships ever constructed in America are the Minnesota and her sister ship, constructed in New London, Connecticut, for the Pacific trade. The Minnesota is primarily a freighter, being 630 feet long, 73 feet in beam, and of

a moulded depth of 56 feet. Her displacement is larger than her length and depth would suggest, as she is much broader towards the ends than the Atlantic liners, which are designed for speed. The result of this formation is that the Minnesota has a little greater displacement than the Kaiser Wilhelm II., and nearly as much as the Cedric.

The Minnesota has the greatest depth of any vessel on the ocean, and is remarkable in several other particulars. Counting from the outer bottom to the bridge there are no less than eleven distinct decks or levels. First is the space between the outer and inner bottoms, which is high enough for a man to stand upright in; then come the orlop, lower, between, main, and upper decks, all within the hull or steel frame of the vessel proper. Above are the upper deck, promenade deck, upper promenade and boat deck, and yet above this is the navigating bridge, the last being ninety feet above the keel. The upper decks are so high above the water that passengers can stay out, even in very heavy weather, without danger of being struck by the combings of the highest waves.

The cargo capacity of the Minnesota is 20,000 tons, and she can carry 150 first-class passengers, 100 second-class, 100 third-class, and 1000 steerage, and in emergency can convey 1200 troops also. The Minnesota is probably the strongest and stiffest of the great steamers, many of which would break in two of their own weight if lifted in the centre. The outer bottom steel shell is made of an inch and a quarter of the best steel plating, the decks are of steel, and stringer plates are worked along from stem to stern between the main and upper decks for stiffening. A continuous central longitudinal bulkhead extends from the keel to the upper deck, checking what are known as "hogging" strains. This is the first bulkhead of the kind, and is half an inch thick through the greater portion. A system of heavy box girders is substituted for ordinary stanchions for supporting the decks, and these, being spaced twenty feet apart, not only enable all the decks to sustain the heaviest loads of freight at any point, but add enormously to the stiffening of the whole structure. There are fourteen hatches for taking in and out cargo, and one of them is large enough to enable a locomotive to be lowered complete into the hold. With a horse-power of only 11,000 in the engines a speed of fourteen knots is obtained.

A particularly American type of vessel is the whaleback, used on the Great Lakes. These are much esteemed as freighters. The illustration affords a very fair notion of the construction.

Among river boats the Priscilla, running between New York and Fall River, is probably the largest and best equipped in the world, being over 440 feet in length and of 93 feet beam. It has feathering paddle-wheels 14 feet wide and 35 feet in diameter, and is credited with a speed of slightly more than twenty miles an hour.

While the preceding descriptions of vessels have been given from an American view-point, as most likely to interest American readers, it must not be forgotten that Great Britain is enormously ahead of us in ship-building, and that, if the United States is ever going to catch up, there must be radical changes of some sort that cannot now be foreseen. The prevailing impression seems to be

Whaleback in Canal Lock, Sault Ste. Marie.

that American legislation should favor American-built ships if the ship-building industry is ever to develop on a scale proportionate with other American industries.

There is space in closing for but one short note in regard to progress in wind-driven craft. It is nothing less than marvellous that, after many thousand years of boat-sailing, some one should be able to construct a sail of a radically new type that should present marked points of superiority over the sails employed for centuries. Yet this is exactly what the new umbrella- or cyclone-sail does. Shaped something like an ordinary umbrella, except that it is elliptical and made in two parts, and practically flat, it is hung by the centre on the mast of a boat, and so arranged that one

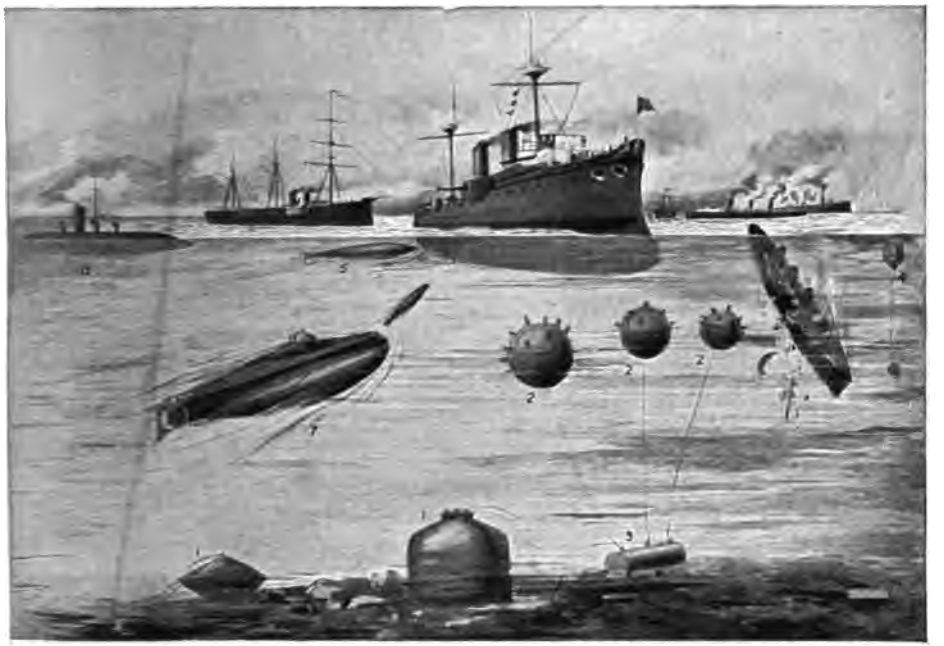
side can be tipped up, the other going down. When a gale of wind strikes this sail, it does not tend to overturn the boat or cause it to careen to one side, but has rather a disposition to life the sail, which acts on the principle of a kite, and has no more tendency to upset a boat than would a kite attached by a flexible string.

The Umbrella-Boat.

The illustration, which is taken from *Popular Mechanics,* shows the original boat which was tried at Cowes, England, in 1903. She is only seventeen feet long, but carries a sail thirty feet in the longest dimension and sixteen feet the other way. This arrangement not only enables a boat to carry a very much larger sail than she could otherwise employ, but also serves as an awning or protection from the sun. For sailing with the wind on the quarter, the mast and sail require to be rotated by means of a turn-table, and there are also other oddities of construction. It is expected that the umbrella-sail will come into large use on small pleasure-boats, canoes, etc.

THE TOOLS OF DESTRUCTION

MAN is naturally a fighting animal; there is no use denying it. A prize-fight will draw a larger crowd at higher prices than a speech by the greatest orator; historians pay more attention to glowing accounts of wars and battles than to the slow growth of industries and science. The passion to fight, perchance to kill, is strong in the race, and it is a question whether civilization has much reduced it. Those who turn their genius to developing



Submarine Mines and Torpedoes.

1, Bottom mines; 2, anchored mines; 3, anchor; 4, anchored mine with tidal adjustment; 5, fish-torpedo; 7, Holland boat discharging torpedo; 8, ram "Katahdin."

engines of war and destruction term themselves peacemakers, because they make the terrors of war so dreadful that it is more likely to be avoided. It is argued that when war means annihilation to both combatants war will cease, and, if this be true, the end must be near, for no one can look over a modern summary of death-dealing contrivances without feeling that well-equipped opposing armies and navies would leave very little of each other after a serious engagement.

With guns that shoot accurately farther than men can see, dynamite mines on land and under the water, and torpedoes that may be discharged from out of the watery depths by a submarine foe, there would be little chance of escape for combatants except through arbitration or the fact of the victor growing weary of carnage. Certain it appears that the great nations of the earth rely on their navies and armies—I say navies first advisedly—to preserve the respect of their neighbors and prevent hostilities, because of the frightful cost of conflict.

Improved explosives constitute the most dreadful weapons of modern times. The gun-cotton and nitro-glycerine of a decade

A Torpedo in its Tube.

or two ago have been highly developed, and we have to-day such explosives as bellite, made of ammonium nitrate and nitro-benzene; melinite, of picric acid and gun-cotton; cordite, of nitro-glycerine, gun-cotton, and petrolatum; lyddite, very similar to melinite; indurite, of gun-cotton and indurated nitro-benzene; maximite, dunnite, and a number of others, of which the methods of manufacture are largely secret, or purposely kept out of print in works of general circulation, in order that evil-minded persons may not manufacture them for the purpose of blowing up their enemies.

The torpedo and the submarine mine, filled with some form of nitro-glycerine or dynamite, such as served to wreck the lamented Maine in Havana harbor, are the forms in which these explosives

are used in warfare. Battle-ships and cruisers are now commonly equipped with two or more torpedo-tubes, while in time of war important harbors are invariably mined, so that any intruding war-vessels can be sent to destruction by the touch of an electric button at the proper instant.

The ordinary torpedo in naval use is of the Whitehead type shown in the illustration. In form it is like a great cigar, and measures from fourteen to eighteen feet in length and fourteen to eighteen inches in thickness. The larger size weighs a little over a thousand pounds, and carries a charge of a hundred and thirty-three pounds of wet gun-cotton, which is sufficient to blow up the best armored vessel afloat if exploded close to it. It is intended

A Submarine Torpedo-Boat.

A, Anchor weights; B, ballast tanks; C, conning-tower; D, diving door; d, diving compartment; E, storage batteries: G, gasolene tank; H, hatches; L, line of spindle hull; O, omniscope; R, horizontal rudder; S, sighting hood; T, torpedo-tubes; W, wheels; X, exhaust from engines.

to be discharged or fired from its tube at a distance of about 2000 yards from the object of attack. The steering apparatus at the tail, which is well shown in the illustration, prevents the torpedo from being turned aside or deflected in its course, while the two screw propellers, operated by a compressed-air mechanism within the torpedo, do the driving. The explosive charge is in the head of the torpedo, and is set off by a pointed rod which protrudes from the nose and is driven in when the torpedo strikes its target.

The submarine boat has been one of the favored means for delivering the torpedo to the vitals of a foe. These little vessels, sailing along with nothing but a few inches of a conning-tower above the waves, can approach a battle-ship in daylight within a

mile or two before going entirely below the surface, and, stealing upon the foe, all unaware of their approach, can send the deadly missile which no steel or armor can resist, but whose explosion means annihilation of everything near by.

The idea of sailing beneath the waves, out of the sight and knowledge of less privileged mortals, is especially captivating, and probably no one who has read Jules Verne's "Twenty Thousand Leagues under the Sea" has failed to register a wish that such

Holland Submarine Torpedo-Boat.

voyages might be possible. While the fabled Nautilus was obviously impracticable in several ways, yet it has since been demonstrated that such submarine travel is possible on a small scale, and with comparative safety, as witness the tests of the Holland boat, the Adder, and others of its class, and of the French Gymnote and Gouber, and the Spanish Peral, as well as many others. The first experimental boats were very faulty, but gradually the designers learned how to overcome the chief difficulties, and the submarine boats of to-day steer readily and can be raised and lowered without difficulty. The fresh-air supply is satisfactory, and theoretically they appear to be a great addition to a navy for torpedo warfare. What they may do in practice time alone can determine. It would

appear that a blockading fleet at a harbor where the defenders had a submarine boat would be in great danger; in fact, the blockade might be impracticable. Certainly the blockading battle-ships would feel obliged to be always on the move, in order that the death-dealing submarine might not steal out on them and deliver its resistless torpedo. Many naval men have no faith at all in the submarine, and criticise it as a toy; but it seems to the writer that the most that can safely be said against it is that it has yet to win its spurs, if one may apply such a simile to a water-craft.

The United States navy has eight of these submarine boats, of which the Holland is the best known. The others, which are more highly developed, being later constructions, are over sixty-three feet long, and have a displacement of 120 tons. On the surface a gasolene engine of 160 horse-power does the driving, and charges the electric batteries, which furnish the power when moving under the waves. There are three water-tight compartments, and flasks stored with fresh air at 2000 pounds pressure. The armament consists of a torpedo-tube capable of discharging a 12-foot Whitehead torpedo. The speed of these submarines when submerged is seven knots, and one has remained below for fifteen hours without accident or discomfort to the occupants.

As an improvement on the submarine boat, it has been suggested that a subsurface torpedo-boat would be equally deadly in attacking the enemy and much safer for the crew. Clarence L.

Burgess' Submarine and Subsurface Torpedo-Boat.
C, Conning-tower; E, engine room; G, gasolene tank; T, torpedo tube; V, ventilating fan.

Burgess is the inventor of the type of subsurface boat here illustrated, which is designed to sail awash, and which would hardly be discernible from the deck of a battle-ship at night, even with rapid play of search-lights. An important feature of this boat is its speed, for it is claimed that it can be driven sixteen knots an hour, while the submarine's chief fault is its slowness. The *American Shipbuilder* says of this craft:

"The subsurface torpedo-boat consists simply of a cigar-shaped steel underwater hull holding the machinery, torpedoes, torpedo-tube, and other vitals and the crew safe from gun-fire, suspended by a hollow fin-like structure, from a distinct steel surface hull filled with cellulose, acting as a mere float to give vision, ventilation, buoyancy, and seaworthiness like an ordinary boat. By the separation of the two hulls, not only are the lower hull and vitals placed well out of reach of shells, but the displacement is halved, so that the necessary speed can be obtained, and the upper hull made low and almost invisible at a distance. A heavily armored conning-tower rises from the lower hull through the hollow fin slightly above the surface hull. This armored conning-tower, in which the navigator stands and steers the boat, is proof against all small guns and is too small a target, in motion, for large guns to hit. The subsurface torpedo-boat being thus barely visible and almost invulnerable to gun-fire, and having a tested speed so much in excess of the ordinary manœuvring speed of fighting ships in battle or on blockade, it is fairly evident that, under cover of darkness, fog, or confusion of battle, and even in daylight, a squadron of these boats could generally be able to get within torpedo range—500 to 1000 yards—and torpedo an attacking or blockading squadron, and get away again without being put out of action."

Ever since the invention of gunpowder a contest has been going forward between the manufacturers of guns and the makers of armor, the one to secure weapons that will penetrate all defences and the other to present an armament that will stop all projectiles. Sometimes the gun and sometimes the armor-plate has been in advance, but generally it is the gun, and the most modern armor-plate only undertakes to present a certain amount of resistance to the impact of projectiles. When the torpedo entered the field with its charge of nitro-glycerine, the armor-plate was no longer fit, and advanced means of defence had to be devised for keeping the torpedo at a distance.

While there have been built some enormous guns, capable of throwing about a ton of metal to a distance of perhaps twenty miles, yet the development of guns of late years has not been in the direction of size; in fact, there has been a tendency to use smaller calibers, and the 12-inch gun is now regarded by many as preferable to the 13-inch or larger bores, and altogether the most efficient large gun that is made A very large gun when fired with the heaviest charges, in the endeavor to reach the greatest distance, receives such strains and shocks that even the best of them would probably not bear the firing of more than a few hundred rounds, and the improbability of hitting anything at ranges above five or ten miles has checked the disposition to build guns of enormous capacity. Instead, the effort now is to produce guns of, say, 6- or 8-inch bore, that can be fired with great accuracy and at a rapid rate. The development in these guns may be judged from the fact that ten years ago a 6-inch gun weighed eleven hundred

to twelve hundred pounds, whereas now it weighs usually eighteen hundred. The former fired its shot with an initial velocity of two thousand feet per second with the brown powder then in use, while the modern gun with its smokeless powder and heavier construction will develop three thousand feet per second, having greatly increased muzzle energy. It has been demonstrated that a 6-inch gun can be fired eight times in a minute, and, discharged at that speed, has been known to strike a 15-foot target at a distance of a mile at every shot. Of course, under ordinary conditions the smoke or gases of smokeless powder would prevent the accuracy of shots sent off with such rapidity; still the record is there, to show the possibilities of rapid fire. Large guns having

An Old-time Fort at St. Augustine, Florida.

projectiles weighing 350 pounds have been fired as fast as four times a minute; but, of course, neither of these speeds can be maintained.

The modern theory is that rapid and accurate firing is of greater importance than the throwing of enormous projectiles to tremendous distances. Guns for use in forts and stationary works are naturally heavier than those used on naval vessels, because of their more secure foundations; but, as a fort is only serviceable for defence, as of a harbor to some large city, and the battle-ship or cruiser is an arm that must go out to attack the enemy, it is the naval gun that attracts the most attention and consideration. Those who have witnessed firing from guns of forts are apt to think

that a ship may be in great danger at a distance of four or five miles; but, as a matter of fact, even shore guns are uncertain at that distance, and when a gun is fired from a ship's deck, subject as it is to the influence of the waves, there can be no very accurate firing beyond three miles, and there are very few naval officers who would expect to damage the enemy much until within a two-mile range. When it is borne in mind that at a distance of two miles a target fifteen feet high, as viewed by a man sighting a gun from a rolling ship, would commonly pass his vision in one-tenth of a second, it will be seen that he must have a very keen appreciation of time to be able to discharge a gun within that extremely brief interval.

While I have spoken of the reduction in the caliber of guns, it should be borne in mind that the projectile has increased in length, and that, whereas a round shot of an old-fashioned 9-inch gun weighed ninety pounds, a long projectile of a modern 6-inch rifle weighs one hundred pounds. In laying out the guns for a war-ship the designer has to consider whether one hundred tons of metal to be thrown at the enemy are best put into 12-inch, 8-inch, 6-inch, or smaller guns. As a matter of fact, it is nearly always divided between these, some proportion or other being figured out as the best for each particular case. The small guns can be fired so much more rapidly than the large ones that they deliver a much greater quantity of metal in the same time. This is apparent from the following figures, compiled by Rear-Admiral O'Neal, chief of the United States Bureau of Ordnance, regarding the practical rate of fire from the guns of the battle-ship Georgia:

Gun.	Muzzle Energy of Gun.	Practical Rate of Fire per Minute.	Muzzle Energy in Five Minutes.
Four 12-inch.	46,246 foot-tons.	0.66	610,447 foot-tons.
Eight 8-inch.	13,602 "	1.2	652,896 "
Twelve 6-inch.	5,838 "	3.5	1,225,980 "
Twelve 3-inch.	709 "	6.5	276,510 "
Total energy all guns in five minutes			2,765,833 "

It will be noted by studying the figures that the 6-inch guns make much the best showing, which accounts for their popularity with designers of war-ships. The capacity of this size of gun has grown greatly in twenty years. It has increased fifty per cent. in length, and throws a projectile of nearly double the former

weight, while the muzzle velocity has also gained about fifty per cent. Many authorities, however, have a preference for the 7-inch gun, now little used, and believe that it is destined to largely supersede the 6-inch. The following table affords farther opportunity for comparison between guns of from 3- to 12-inch caliber:

Caliber of Gun.	Weight in Tons.	Length in Caliber.	Approximate Charge of Smokeless Powder for Maximum Velocity.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Perforation at Muzzle. Krupp Armor. Projectiles. Capped.	Perforation at Muzzle. Krupp Armor. Projectiles. Uncapped.	Remaining Velocity at 1000 Yds.	Perforation at 3000 yds. Krupp Armor. Projectiles. Capped.	Perforation at 3000 yds. Krupp Armor. Projectiles. Uncapped.
			Lbs.	Lbs.	Ft.-secs.	Ft.-tons.					
3-inch	0.87	50	5	13	2800	709	4.4	3.6	2130	. . .	. . .
4-inch	2.56	50	15	32	2900	1,870	6.4	5.6	2380	3.2	. . .
5-inch	3.3	50	27	60	2900	3,503	8.4	6.6	2460	4.6	4.6
6-inch	8.37	50	46	100	2900	5,838	10.9	7.3	2525	5.9	5.2
7-inch	13.33	45	74	165	2900	9,646	13.2	10.5	2580	8.3	6.5
8-inch	18.	45	115	250	2800	13,602	15.	12.1	2530	10.3	7.9
10-inch	33.4	40	240	500	2800	27,204	20.	17.1	2585	15.	11.5
12-inch	52.	40	385	850	2800	46,246	25.	21.7	2620	19.5	16.2

Courtesy Scientific American. A Rapid-Fire Gun, with Shield.

A comparison of the larger modern guns is afforded by experiments made at Sandy Hook, in January, 1903, with a new 16-inch United States army gun, the results of which are placed in the following table together with figures obtained in a test of a modern 12-inch Krupp gun:

Type of Gun.	Bore in Inches.	Total Length in Feet.	Weight in Tons.	Weight of Projectile in Pounds.	Weight of Powder in Pounds.	Kind of Powder.	Muzzle Velocity in Feet per Second.	Muzzle Energy in Foot-tons.	Muzzle Energy in Foot-tons per Ton Weight of Gun.
United States Army .	16	49.7	130	2400	640	Nitro-Cellulose Smokeless	2306	88,000	677
Krupp	12	50	57.6	*771.6	334	Nitro-Cellulose Smokeless	*3330	59,280	1029

* Since the velocity falls off much more rapidly in the lighter shell, the remaining velocities will be proportionately greater in the 2400-pound projectile.

This great 16-inch gun cost $155,400, of which $5400 was the bill for transportation from Watervliet to Sandy Hook. Each time it is fired the cost is $865.

The 16-inch Gun at Sandy Hook.

From the Sandy Hook test it was calculated that the maximum range of the 16-inch gun was twenty-one miles, this with an elevation of forty degrees; also that the energy developed was sufficient to drive the 2400-pound projectile through 27½ inches of steel armor at a distance of two miles. It has been calculated that a Brown segmental gun of 4½ inches caliber, with a long 55-pound projectile, will stand a powder-charge that will give a muzzle velocity of 4000 feet per second, and, if this is correct, it should have a range of almost twenty-four miles; but whether these enormous distances could be reached in practice is doubtful. Guns strained to the limit are apt to burst with frightful results, and aiming them accurately at such distances and with the required elevation is out of the question.

The disappearing gun, for use in forts whose location it is desired to hide as much as possible, is an American product. The Buffington-Crozier patent is the type in most favor. Some of

these are installed at Fort Wadsworth, covering New York harbor. This gun has the trunnions mounted on a pair of grasshopper-like legs or levers. In firing position these legs are upright, and when the gun is discharged, they bend over and down, compressing the hydraulic chambers, thus securing the recoil. Incidentally the gun is brought to a lower level, below the parapet, whence it receives the name of disappearing gun, being kept out of sight when not in actual use.

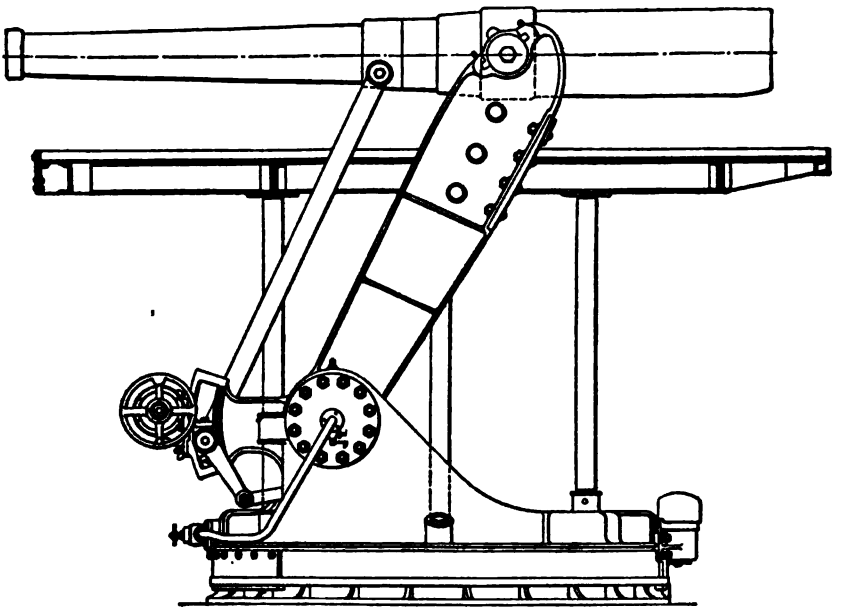


Diagram showing Mechanism of a Disappearing Gun.

The name of Krupp must ever be linked closely with the growth of big guns and of armor-plate. Alfred Krupp came most conspicuously before the world in 1851, when he succeeded in making a forty-five-ton block of steel, this being more than double the size of any previous large steel forging. He thus demonstrated the practicability of making large steel guns, and in 1855 had improved his processes so that he was able to produce a one-hundred-ton block of steel. From this time the Krupp concern took first place among the manufacturers of great guns, which position it has retained ever since, the works at Essen being the largest in the world, and equipped in the most complete manner. One feature which assisted their development was the establishing of proving-grounds for tests. At these grounds shots can

be fired to a distance of fifteen miles or more without interfering with the outside world.

The cast-iron gun of the Civil War did not admit of using a heavy charge of powder, and was thought to do well when it started a shot on its way at a velocity of 1500 feet a second. This gun was improved by a hoop of iron shrunk over the breech, and, this method proving successful, the practice of placing one hoop

Courtesy Scientific American.

Breech Mechanism of a Large Gun.

over another resulted in the built-up gun, which has a marked increase in strength over the cast gun and has been the standard gun for many years, the best of them showing a muzzle velocity of about 3000 feet per second.

As an improvement on the hoop, Mr. Longridge, of England, suggested the wire-wound gun to the Armstrongs. This gun consisted of a steel tube wound about with a ribbon or thin band of steel plate, employing great tension during the winding, so that

the tube was enormously strengthened. The reason why the wire or ribbon of steel wrapped around the gun in this fashion made it stronger than the same amount of metal in hoops is, that the greatest strength is obtained in steel when it is worked down to small sizes by compression, consequently these ribbons of steel possess a much greater tensile strength than can be secured in large hoops. Farther, the tension of the wire can be regulated so that compression strains of known quantity can be secured at various distances from the bore. Where the tension is properly applied, the strain of a bursting charge is equally divided between the layers of wire, instead of being greatest near the bore.

Courtesy Scientific American.

Section of a Brown Segmental Gun.

The Brown segmental wire-tube gun has passed tests of a remarkable character. It is formed first of an inner lining tube, then comes a segmental core, then the wire, and, lastly, the outer jacket. The segmental tube consists of a series of thin plates of steel tapered towards the muzzle and clamped together so as to grip the tube. These plates are cold-rolled to their finished size. This rolling produces the highest degree of strength in the metal, and is comparatively inexpensive.

The smaller naval guns, as the 3-pounders and 1-pounders, are now commonly automatic or semi-automatic in their operation,

and are intended for close fighting, such as may occur in the repulse of torpedo-boats or in making a landing. A 3-inch gun, which mounted on a carriage weighs 1200 to 1500 pounds, can be handled readily by man power, and is commonly preferred for a landing gun. Among the improvements made of late years in large guns is the general adoption of telescopic sights for giving greater accuracy of aim. The discharging of guns by electricity has also become quite common, as permitting the quickest action. Automatic ejectors for the primers are in general use, and there are several improvements in fuses. In guns of modern construction, there is a sleeve which carries the trunnions and in which the gun recoils. Upon this sleeve are mounted the sights, and the platform for the man who aims and fires the gun is also on the sleeve. Thus the man moves with the recoil, and is not thrown out by it, but is ready promptly for the next shot.

The breech mechanism, whose quick operation assists so much in rapid fire, is shown in the accompanying illustration, page 186. All modern guns of 3-inch and upwards are fitted with the Welin patent breech-plug, which is threaded in steps. The breech can be opened, closed, and tightened in a very short space of time, and it is now the loading of the projectile and the aiming of the gun that consume most of the time, and thus determine the rate of fire, although the heating of the gun also serves to check the speed.

In the case of 12-inch and 13-inch guns the recoil is taken up by hydraulic cylinders, of which four are commonly employed. The 12-inch guns of the Maine recoil thirty-three inches and have metal springs as well as hydraulic cylinders, and the former return the gun to position after the recoil.

Improvements in steel-making are responsible for a considerable part of the improvement in modern guns, resulting in gains of fifty per cent. or more in strength for the same weight, during a dozen years. Gun-steel forgings are now made with as great as 70,000 pounds elastic strength, and about 130,000 pounds ultimate or breaking strength.

The arrangement or disposition of large guns on battle-ships and cruisers may be gathered by those interested from the chapter entitled "The Race for Supremacy on the Seas," in which a number of naval vessels are described.

The use of smokeless powder has been perhaps the most notable development of gunnery of recent years. The absence of a cloud of vapor is not the only merit of this modern powder. In

the old powders about forty per cent. of the charge remained in solid form, and constituted a useless and cumbering addition to the charge, interfering with the development of the most energy, as well as forming the obstructing cloud of smoke. The new powder is commonly pure nitro-cellulose, more familiarly known as gun-cotton, and when it explodes almost the entire amount is turned into gas, which assists the projectile in its course. It has the disadvantage that the nitro-cellulose has a tendency to score

Old-time Wooden Gunboat Vermont, United States Navy Yard, Brooklyn.

or gutter the gun in the bore; the higher the pressure under which the gun is fired the greater is the destructive power of the gas on the interior steel. In manufacture the nitro-cellulose is made up into a gluey compound and forced through a series of small holes in a plate, thus taking the form of little sticks that may be likened in appearance to macaroni; or it may be made into pellets or grains.

Armor-plate for protecting battle-ships and cruisers has been so improved in the last generation that a foot of the best of to-day will withstand more than two feet of steel of, say, twenty-five years ago. We used to make steel plates by hammering under the steam-hammer; then Krupp had a process of rolling them under enormous pressures; now they are subjected while hot to hydraulic forging, in which steady pressure of great amount affects the whole mass of the plate, rendering it more homogeneous, and consequently stronger throughout and freer from possible flaws. After forging in this way the plates are sawed or planed to size and then Harveyized by cementation, hardening, and tempering. This surface-hardening adds about twenty-five per cent. to the resistance of the plate. The Krupp process, which may be called an improvement

on the Harvey, is responsible for another gain of about ten per cent. in resistance.

Armor Plates Tested by Gunshots.

Courtesy Bethlehem Steel Works.

In either of these processes nickel is introduced in the steel in the furnace, this composition being stronger than pure steel. In

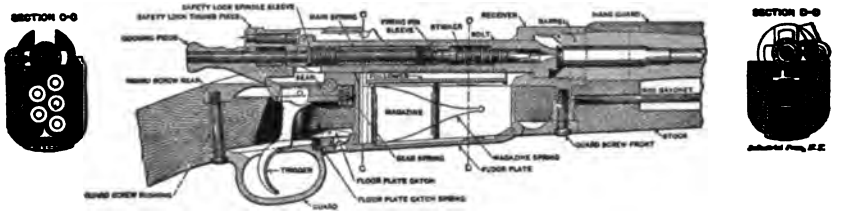
the Krupp process the face-hardening is carried much deeper into the plate, owing largely to the use of a gas furnace. While it might be inferred that this hardening of the plate would tend to induce cracking by increasing the brittleness, this is obviated by the extreme toughness of the unhardened backing of the plate. A 12-inch Krupp-ized plate will withstand the impact of a number of 12-inch shells at velocities of 1700 feet per second or more, the penetration of such shells, delivered at right angles, being usually from four to six inches, the shells being smashed on the plate. Torpedo shells, however, having a striking energy of over 50,000 foot-tons, and weighing 1800 pounds, will crack such a plate, a few shots demolishing it.

Machine-guns, firing billets from a series of barrels, have reached a high degree of perfection. During the Civil War we had the Gatling, in which the cartridges were automatically fed by a crank mechanism. In a modernized form it is mounted like a small cannon, and has ten barrels, which are loaded and discharged in rapid rotation, several hundred shots a minute being fired. Hotchkiss, Nordenfelt, Maxim, and Benet have made important improvements in this type of weapon, utilizing the force of the exploding powder to operate the discharging of the shells and feed the cartridges to place, so that once started the gun is automatic in operation as long as cartridges are in the supply-belt. These guns have been constructed to fire more than a thousand bullets a minute, but the number exceeds utility, and they are now usually constructed to discharge 250 to 400 bullets in that time.

The common form of small arm is a magazine rifle, of which the Krag-Jorgensen is used largely by the United States infantry. The Mauser and Lee-Metford are other well-known makes. In the most modern of these a small stock of cartridges is stored above the trigger mechanism, or sometimes in the stock, and automatically fed into the breech of the barrel, being set off by a firing-pin. All that is necessary for their operation when supplied with cartridges is the pulling of the trigger until all the bullets are delivered. The modern bullet, like the projectile of great guns, is long and cylindrical, and, though of small caliber, when used with smokeless powder, has great penetrating power.

The new Springfield rifle, recently adopted by the United States army, is the most formidable yet introduced. Its range is five miles, the initial velocity of the bullet being 2300 feet per second, enough to drive it through four and a half feet of white pine. It is very light and small, being only forty-three inches long, so that a cavalryman

can use it. The magazine holds five cartridges, and the mechanism is well shown in the illustration.



Springfield Rifle Mechanism.

A most interesting device for enabling a sharp-shooter to fire from behind a breastwork has been invented by William Youlton, an Englishman, who drew his inspiration after the battle of Colenso in the Boer war. The instrument is called the hyposcope, and is designed to be attached to a rifle, and enable the user to take aim while his head is a foot below the sights of the rifle, and consequently may be safely protected behind a rampart. The device contains,

Courtesy The American Inventor.

A Rifle fitted with a Hyposcope.

of course, a system of reflectors somewhat similar to the looking-glasses used by trick shooters on the stage. A number of these instruments were made and used during the latter part of the Boer war, and an illustration of one is shown herewith. It will be noted that the hyposcope is secured to the rifle near the breech. The cross-piece lying over the top of the rifle bears its first mirror in line with the sights and reflects the light to the second mirror at the elbow of the instrument, and this mirror directs the rays downward to the point where they are caught by another mirror opposite

the eye-piece. When the mirrors are properly set, the marksman at the eye-piece sees the reflection of the two sights, and when he gets them in line with the object can fire the rifle as accurately as if his eye were at the usual place back of the rear sight. The instrument is made adjustable as to the length of the upright piece, which is telescopic. There are devices to allow for windage, the same as for first-class rifles fired in the ordinary way. The mirrors are small affairs, so made that when one is broken it is easily renewed.

It would appear as if the use of the hyposcope might very largely change the nature of future warfare. A garrison of men well intrenched could protect themselves and hold a place until they were starved out. A conspicuous advantage would be increased accuracy of aim. Without a hyposcope a soldier who fires over a breastwork is almost sure to take hurried aim, because if he does not retire quickly he is as likely to be shot himself as to shoot some one on the other side. With the hyposcope he can take a rest on the top of the rampart and aim as deliberately as he pleases, the probable result being that any but the briefest exposure on the part of an enemy would result in the majority of cases in his being shot.

The New Magazine Pistol.

The deadliest pistol in the world has recently been placed on the American market, and its very simple mechanism will be easily understood from the accompanying print. The cartridges are stored in the handle, and can be set off as fast as the trigger can be pulled. The extreme simplicity of this small arm, which is only seven inches long and weighs but twenty-three ounces, will probably bring it into extensive use, though, if such death-dealing tools are to become common, legislation will be required to prevent their being generally carried by those foolish people who imagine that they are never safe without "guns" in their pockets.

SOME GREAT CANALS AND TUNNELS

THE canal is one of the oldest of engineering enterprises. After men learned how to navigate rivers and proved that transportation by water was much easier than by land, they began to construct artificial water-ways in order to make convenient connections. Tradition informs us that a canal was built at the Isthmus of Suez, in the time of Sesostris, thirty-five centuries ago. Notwithstanding the development of railways, the canal seems to hold its own, and

High Mine Canal, Platte Cañon.

old canals are kept up, while new ones are contemplated all over the world. When once built, they afford cheap transportation for freight, but their construction is very costly. While many canals have gone into disuse, because built in sections where railroads can better serve the purpose, yet there is great activity in their construction, and hardly a civilized nation exists that has not in hand or in prospective the building of some great canal. All America wants Panama cut, New York State wants to spend $100,000,000

in improving her canals, England wants several large canals, the French are always discussing one from the Mediterranean to the North Sea, and Italy and Austria have canal enterprises in consideration.

The tunnel is a first cousin of the canal; both involve delving into the ground, breaking up the rock, and excavating vast quantities of earth. The workmen employed in each case are similar,—civil engineers to lay out and plan the work accurately, experienced mechanics to direct the work, and gangs of laborers to do the heavy tugging, that requires much strength and little skill. Both are very costly undertakings, and run into the millions for short distances, though the costs have been very much reduced within the last twenty years by improved machinery.

Irrigation Canal, Stockdale, California.

The Suez canal is almost invariably referred to as the greatest canal in the world, yet the number of vessels, or technically the "tonnage," passing through it annually is not equal to the number that pass through the canals connecting the Great Lakes of North America. The former is the longest of ship canals, being ninety miles from end to end, of which about two-thirds is through shallow lakes. In 1895 the Suez canal was enlarged, giving it a depth of thirty-one feet, and a width at the bottom of 108 feet, and at the surface of 420 feet. With these improvements the cost of the canal is a little over $100,000,000. The construction of the Suez canal has led to the rapid development of steamers for the Eastern trade, has brought about the disuse of sailing-vessels in that trade, and has vastly increased direct trade between the East and Europe.

The ship canals of the Great Lakes are several in number, beginning with St. Mary's, or Sault Ste. Marie canal, which though short is very important; then the Welland, which is the longest of the series, followed by the Galops and five smaller canals; the whole forming a continuous water connection from the head of Lake Superior to the mouth of the St. Lawrence. Taking the record of the tonnage passing through St. Mary's canal, I find that in 1889 it equalled that of the Suez canal, being about 7,000,000 tons; in 1895 the tonnage at St. Mary's was 15,000,000, as against 8,500,000 for the Suez; and in 1901 the figures at St. Mary's were 28,403,065 tons. The value of the freight passing through St. Mary's is not as

Locks of Sault Ste. Marie Canal.

great, however, as that passing through the Suez, the latter being perhaps twenty per cent. in advance in 1900. The St. Mary's canal, which connects Lake Superior with Lake Huron, was begun by the State of Michigan in 1853, being dug out to the length of a little more than a mile and to the depth of twelve feet at a cost of $1,000,000. The United States Government in 1870 began to enlarge the canal, and by 1881 its depth was increased to sixteen feet and the width and length correspondingly added to. In 1887 further improvements were undertaken by the United States, which were continued from time to time until in 1896 the depth was increased to twenty-five feet to meet the continual demands of increased traffic.

The Welland canal connects Lake Ontario and Lake Erie on the Canadian side of the river. It was constructed in 1833 and enlarged in 1871 and again in 1900. The length of the canal is twenty-seven miles, the number of locks twenty-five, the total rise of lockage 327 feet, and the total cost about $25,000,000. The annual collection of tolls on freight, passengers, and vessels averages about $225,000, and the canal is open on an average about 240 days in a year.

Interior of Power-House, Sault Ste. Marie Canal.

The next most important ship canal of the world is probably the Manchester canal, opened in 1894. This is thirty-five and one-half miles long and has a width of 120 feet at the bottom and an average depth of twenty-six feet. It cost $75,000,000, and the yearly expenditures are nearly $2,500,000, which are more than paid by the tolls.

The most important canal of Germany is the Kaiser Wilhelm canal, completed in 1895, having a length of sixty-one miles and terminating in the harbor of Kiel. It is twenty-nine and one-half feet deep and seventy-two feet wide at the bottom, cost $40,000,000, and affords passage for about 25,000 vessels annually. Other important ship canals are the Cronstadt and St. Petersburg canal, completed in 1890 at a cost of $10,000,000; the Corinth canal, completed in 1893 at a cost of $5,000,000; and the Elbe and Trave canal, connecting the North Sea and the Baltic, opened in 1900, and costing nearly $6,000,000.

The Chicago sanitary and ship canal connects Lake Michigan and the Illinois River at Chicago, and is thirty-four miles long. This canal is peculiar from the fact that it was cut principally for the purpose of giving proper drainage facilities to the Western metropolis by turning the water that formerly flowed into Lake Michigan into the Illinois River at Lockport. The work was completed in 1900, at the enormous cost of $34,000,000, of which about $3,000,000 was paid for rights of way and $4,000,000 for building bridges over the canal.

The United States has thirty-nine canals worthy of the name; nine of these are over one hundred miles in length: the Erie is 387

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A Modern Canal Lock.

miles, Ohio 317, Miami and Erie 274, Pennsylvania 193, Chesapeake and Ohio 184, Lehigh 108, Schuylkill 108, Morris 103, and Illinois and Michigan 102.

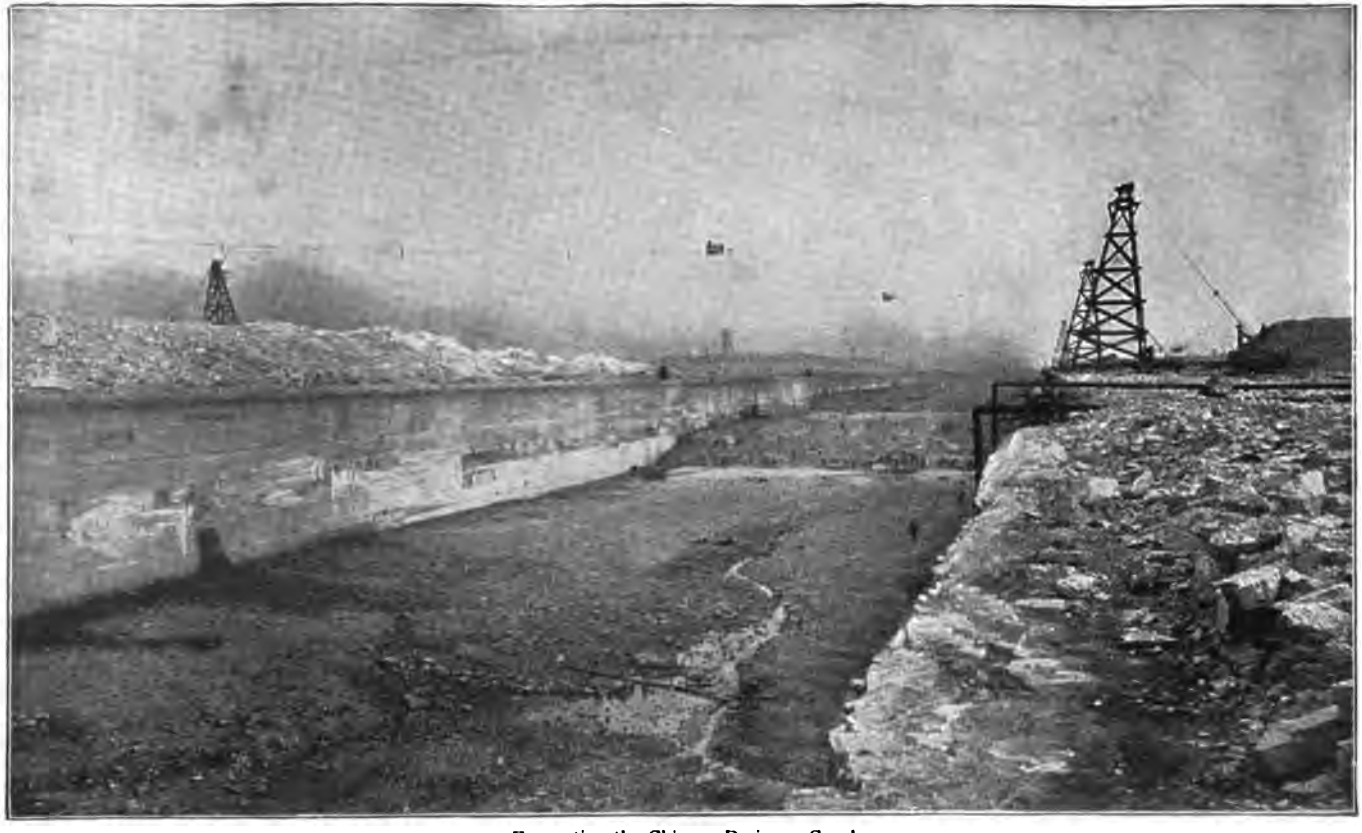
A chapter on canals would hardly be complete without some discussion of the proposed canal at the Isthmus of Panama. The same arguments that caused the building of the Suez canal apply with equal force to a canal joining the Atlantic and Pacific across the narrow strip of land connecting North and South America. It is a fact that the building of this canal has been discussed for nearly 400 years, and that while it is more needed now than it was at any earlier period, it is yet unbuilt, although the amount of energy expended in discussing the problems and the relative advantages of the Panama vs. the Nicaragua route, if properly directed, would have been sufficient to complete the canal long ago. That President Roosevelt was right in recognizing the new state of Panama, and arranging for a canal there under United States con-

trol, is now generally conceded. Summed up briefly, the geographical conditions are these: the Panama route is forty-nine miles long, as against 186½ miles for the Nicaragua. The shorter route would save vessels passing through about twenty hours of travel. The Panama route alone is feasible for a sea-level canal, though both are practical for a canal with locks, which latter is the plan generally favored regardless of the route. Though the Panama route is much shorter, the land to be cut through is of greater height, while the Nicaragua route is aided by the use of Lake Nicaragua and the San Juan River.

The American Commission appointed in 1899 to investigate the subject wrote to Congress their estimate of the cost of the Nicaragua route as $189,000,000, and by the Panama route as $144,000,000; also that the cost for maintenance and operation would be more than one-half greater for the Nicaragua route. These figures aided in directing public sentiments in favor of the Panama route, and before many years its existence will be a matter of history.

In building a canal the engineers must first lay out the route, and if it be through high ground, where locks are necessary, they have to arrange the upper levels so that they may be fed with water from near-by streams or lakes, that are certain to give a sufficient supply to keep the canal always full. When the work of the engineers is completed on paper, the actual work of digging may begin. The modern method of construction consists in placing movable steel towers on either side of the excavation and running wire cables across. From these cables are suspended huge buckets, into which the laborers dump the loose earth or broken rock as fast as it is in readiness to be moved. The rock is all broken by blasting, the rock-drill being used to perforate the stone, and charges of dynamite inserted to break it up into sizes that can be conveniently handled.

On the Chicago drainage canal one of these cableways has been known to remove over 11,000 cubic yards of rock in less than 200 hours. The steel towers which support the cableways were set on temporary railway tracks that were constructed on either side of the canal, so that they could be pushed along as the work progressed. In the sections of work where the excavation was all rock, the plan of operation was to use a channelling machine to cut the sides of the canal, and then utilize the rock-drills to bore a row of holes across the space to be cut out. When a row of holes was completed to a depth of about twelve feet, dynamite was sunk into



Excavating the Chicago Drainage Canal.

the holes and the row fired off all together. The broken rock thus obtained was loaded by laborers into skips, as the receptacles are termed that are suspended from the cableway. When a skip was full, it was drawn away by a wire rope wrapped around a drum at the tower, and driven by an engine, a method permitting the contents of the skip to be carried off and dumped on either side of the canal. In the case of very large rocks, a chain was simply passed around them and they were hooked on to the travelling

Courtesy Ingersoll-Sergeant Company.

A Rock-Drill.

carriage. As used on the Chicago drainage canal, the steel towers were generally 700 feet apart, the head tower being ninety-three feet high and the tail tower seventy-three feet. The reason why the towers were set so far apart was to afford a large dumping ground for the material taken out of the canal. The Lidgerwood cableway is here pictured, as used on section eight of the Chicago

canal. As the average depth of the cut through the rock was from thirty-three to thirty-six feet, the machines employed for channelling were designed to cut down twelve feet, the same distance that the rock-drills operated, and in this way the material was removed in sections or lifts of twelve feet at a time. It was customary to use one cableway for the first lift, and after it had progressed a little distance a second cableway operated on the second lift, and later a third was started on the lower lift.

Where loose soil was encountered, the steam-shovel was employed, and, in the sections of the canal which ran through earth, inclined and bridge-conveyors were employed for carrying away the dirt. The total excavation on this canal was 12,200,000 cubic yards of rock and 37,500,000 cubic yards of earth.

The construction of tunnels comes naturally in connection with canals, because both involve such huge digging operations, with blasting and removal of material. In the tunnel, however, the engineer has to consider methods of ventilation and means of roof support, and he has much reduced convenience for disposing of the earth and rock removed, all of which must be sent back through the cut or drive as it is completed. The tunnel is usually a short cut through some mountain, just as the canal is often a short cut between two natural water-ways.

The famous tunnels of the world are the Mont Cenis, cutting through the Alps from France to Italy, and opened in 1871, at a cost of $15,000,000; the St. Gothard, opened in 1881, the longest of all, nine and a half miles, at Uri, Switzerland, affording a railway connection between that state and Italy, and costing over $11,000,000; the Arlberg, opened in 1884, and costing over $7,000,000; and the Hoosac, on the Boston and Albany line, completed in 1875, at a cost of about $16,000,000. To these must now be added the Simplon tunnel, cutting the Alps between Switzerland and Italy, begun in 1898, and to be finished in 1904. The contract time allowed for the latter was five and a half years, which is pretty short, when it is considered that the St. Gothard required seven and a half years and the Mont Cenis thirteen. But methods of tunnel-building have improved, which made the task possible in the shorter period, and also reduced the cost about one-half.

The Simplon tunnel will lessen the distance of travel between Paris and Milan by nearly a hundred miles. It will withdraw travel from both the St. Gothard and Mont Cenis tunnels, but no doubt all of them will continue to be profitable, as the very exist-

ence of tunnels tends to increase traffic. The Simplon tunnel is unique in that, instead of being a single two-track tunnel, it is composed of two separated single-track tunnels, communicating

Courtesy Scientific American.

A View in the Simplon Tunnel.

at intervals for ventilation. During the work upon one side of the tunnel the other side was used as a ventilating tube, and the plan proved very satisfactory. When it is remembered that over thirty thousand pounds of dynamite are exploded in this tunnel each

month, in making the blasts, the necessity for superior means of ventilation during building is apparent.

As with all large tunnels, the work proceeds from the opposite ends, working towards the centre. So sure are the engineers of their calculations and measurements that they would pursue the same policy if a tunnel were fifty miles in length. When the workers from the opposed sides meet, there is not usually more than a few inches of deviation discovered between the lines of their timbering. Rock-drills drive the holes into the forward breast upon which the men work, anywhere from eight to twenty holes

Courtesy Scientific American.

Spree Tunnel, showing Hydraulic Shield.

being driven to a uniform depth, which may vary from four to ten feet, according to conditions. When the holes are bored, the dynamite is put in, the laborers draw back and the blast is set off. If the soil is loose or the rocks tend to slide, a tunnelling shield is used to protect the workers, this being advanced as the work progresses. In the case of the Simplon tunnel electric power was used to drive the rock-drills, the dynamos being driven by water-power which happened to be convenient. Hydraulic drills were used, driven by water under high pressure, thus securing rapid working.

Tunnelling under rivers is radically different from mountain tunnelling. Flooding has to be provided against at all times, and, as the work often progresses through soft soils, gravel, clay, or mud, the problems for the engineer are very different. A hydraulic shield is used, which is pushed forward by means of hydraulic jacks. There are doors in the shield through which the workmen may remove the earth or small boulders, but there is always a pressure of air in the rear to prevent the water coming in. In other words, air-locks are provided and compressed air is supplied to the workmen as the shield progresses. When a certain amount of advance

Courtesy Ingersoll-Sergeant Company.

Tunnelling under East River.

has been made an iron or steel ring, somewhat oval in form, is set into place to form the walls of the tunnel. The rings are made oval in order that they may be passed through the section of tunnel already completed. If the rings are very large they are made in segments, and then it is not necessary to make them oval, as the parts are brought in singly and put together at the final position.

In tunnelling through loose soils where there is no danger from flooding, as in building a subway in a city, it is cheaper to advance the work with sheathing of planks or metal "needles," which protect the sides and top of the work, and which are easily driven in where wanted and easily removed after they have served their purpose.

It is estimated that there are about twelve hundred tunnels in the world, of which more than a thousand have been built by railway companies for their own use, and nearly a hundred for the passage of canals. As improved methods reduce the cost, and as demand grows for more direct routes, tunnels become more common. One of these days it will be thought nearly as easy to bore through a mountain as to build a road around it.

The subways of great cities are a form of tunnel too well known to require much space here. London and Paris were first

Courtesy Scientific American.

Station in the New York Subway.

to employ them for underground railways. Within a decade Boston, Chicago, and New York have built extensive subways. Nearly a hundred miles are built or building under Chicago, while New York city has fifty-eight miles built, in course of construction, or contracted for. Tunnelling under cities comes as a necessity growing out of the crowded conditions. When the travel overcrowds and cannot be turned any other way, the subway is the final resource. It has its dangers, as the Paris horror of 1902 testifies, but some of these are not apparent at first sight. *Popular Mechanics* emphasizes one peril in time of war, alleging that miscreant spies could use the tunnels to blow up our large cities. It argues:

"The United States could not possibly do anything that would add more greatly to the strategic advantages of a future enemy than to permit the building of these tunnels. The cities that are thus endangered by being undermined with the tunnel systems are New York, Chicago, and Boston. In either of these municipalities, one hundred men with less mechanical and inventive genius than an Edison could work more ruin than a whole fleet of war-ships, even should the ships be allowed to ply their work of the destruction without opposition.

"In America there are sympathizers of every country on the globe. Should war be declared with any nation, there would be thousands of men here who would be ready to aid the opposing nation. Being already on the ground, they could easily form a secret organization, and, with the advantages the United States itself has afforded them by building these tunnels, they could inflict untold punishment on us and escape with little danger of detection. But even without

The Chicago Tunnel Sewer.

these sympathizers it would not be a very difficult matter for the enemy to slip spies into these cities from different points of the Americas to perform the work.

"Bombs of the most powerful explosives made into deceptive forms could by various methods be placed at intervals along the tunnels and set off mechanically at a given moment. Then there would be an explosion more terrible than an earthquake and possibly as disastrous as the eruption of Mount Pelée. The entire foundation of the city would be shattered. Skyscrapers would reel and fall and all structures along the routes of the tunnels would be demolished. Street cars, electric wires, and the crazed populace would be buried in the mass of riven ruin; and the resultant conflagration that would soon sweep over the entire city would complete the work of devastation."

Lest the reader may be unduly frightened by these appalling suggestions, it is well to remember that civilized nations do not approve of war carried on by using high explosives to blow up non-combatants, and no nation that would undertake to fight the United States would be likely to use these methods, preferring an agreement that both sides abstain from such barbarities.

GREAT FARMS AND FARMING MACHINERY

AGRICULTURE as an industry demands a high degree of intelligence, a wide knowledge of conditions, and all-around business ability of a very high order. The most successful system of farming is that which yields the largest financial returns without impoverishing the soil for subsequent crops. It is a wise man as well as a strong one who can judge most certainly how to secure the best results from his land, in the face of sharp competition and the uncertainties of climate and of the market. The reason why there are fewer successes in agriculture than in commerce and manufactures is because it requires more keenness of perception, more persistency, more training, and more knowledge of details to be a good farmer. The most conspicuous successes have been made in specialties, as raising wheat on a large scale, cattle raising, truck farming, and fruit farming. While the majority of farmers are not rated as successful men, neither is the average business man, and there are more failures among merchants and manufacturers than among agriculturalists. If the farmer finds his affairs in bad shape, he can usually retrench, and take some sort of a living out of the soil; whereas the business man who begins to lose money is very apt to fail and involve others in his losses.

During the past generation a vast number of the small farmers of New England and the older sections of the United States were practically forced out of business by the development of the great farms in the West and Northwest. The hilly lands of the East, frequently rough and stony, and always cut up into small farms, proved unable to compete with the vast areas of level ground, cultivated and harvested in a wholesale manner by a class of machines that could not possibly be employed on small farms or on rough ground. Owing to these vastly different conditions, the methods of farming are totally different in the West from those prevailing in the East, and the growing of heavy crops, such as wheat and hay, are left almost wholly to the great Western farms, while the small farms of the East are in many cases reduced to farming for local consumption only, to raising of truck or vegetables for the cities near by, and also to the raising of small fruits, especially apples, peaches, and grapes, or the growing of tobacco.

An idea of the vastness of some of the Western wheat farms

may be gained from the statement that the Mitchell farm, in San Joaquin Valley, California, comprises 90,000 acres; while the Dalrymple farm, in North Dakota, is not far behind, with 70,000 acres. The latter farm has employed as many as 300 binding reapers to harvest its wheat crop. Near the town of Clovis, Fresno County, California, is a wheat field containing forty square miles. As the ground lies almost in an exact square, it presents during the season just before harvest the appearance of an endless sea of waving grain. This is the sort of wheat field of which the statement has been made that the men and teams breakfast at one end of the furrow, take dinner at the other end, and return at night to the point of starting. If a single man were to undertake to plow

Reaping in a Field of Wheat.

such a field in the old-fashioned way, it would require sixteen years for him to complete his spring plowing, as much longer to do the harrowing, and, if he were fortunate, he might finish sowing the seed before he died; but, though the preparing and sowing would occupy one man's lifetime, 300 modern steam harvesters and threshers can make comparatively short work of the harvest in even an enormous field such as this. One of these machines with a 26-foot cutter is expected to do seventy-five acres per day.

Corn, wheat, oats, barley, rye and rice constitute about one-half of the total value of plants grown in the United States, the corn yield alone in 1902 being worth a little over a billion of dollars, a figure that will surprise many who do not realize the enormous acreage devoted to this crop. A slight improvement in the

average growth of corn may mean many millions of dollars added to the wealth of the country. The Department of Agriculture has been carrying on experiments at a station in Illinois for several years, with a view to improving corn by methods of selection, and the increase in production has been so great that it has been proven that, if all the farmers in the State had practised the methods followed at this experiment station, the value of the corn crop of Illinois for one year only would have been increased by $20,000,000! The leading farmers of the State were so impressed by the results that they formed the Illinois Seed-Corn Breeders' Association, for extending the work and encouraging and promoting the growing of pure-bred corn for seed.

This movement has not only resulted in an increased production as measured by bushels, but the character and quality of the grain itself are being studied and improved. Methods of fighting corn-smut, the principal disease of corn, have also made strong progress through the efforts of the Department.

The wheat crop of the United States for 1902 was valued at $422,000,000, of which about one-third was exported, either as wheat or flour. As the yield per capita is smaller than it was some years ago, the conclusion is that after another generation we may cease to be exporters of wheat, requiring all our crop for home consumption. Improvement in wheat cultivation has been less marked than with corn. The farmers in many cases seem to raise it on land that they do not know what else to do with, and the average yield, under an average lack-of-system tillage, is but thirteen bushels per acre. When it is remembered that well-tilled land can be made to produce thirty bushels per acre every year, it becomes very apparent that there is a great work to be done in this country in reforming the present slack methods of wheat growing. Our agriculturists have been giving their attention to developing wonderful planting and harvesting machines, but have generally neglected high tillage, which is essential to large crops. The Department of Agriculture is doing good work in calling attention to this condition of affairs.

The growing of rice has increased very rapidly in the United States within a few years, the yield in 1902 being 331,000,000 pounds, as against 115,000,000 pounds in 1898. Louisiana and Texas are the principal centres of this increased production, which is adding greatly to the value of farms in those States.

The hay crop of the United States in 1902 was reported by the Department of Agriculture at 59,857,576 tons; potato crop, 284,-

632,787 bushels. The census of 1900 gave the hop crop, 208,000 bales of 180 pounds; flaxseed crop, 20,086,000 pounds; hemp crop, 11,750,630 pounds; peanuts, 11,964,957 bushels; sweet potatoes, 42,526,696 bushels; apples, 175,397,626 bushels; peaches, 15,433,623 bushels; pears, 6,625,417 bushels. In 1902 the wheat crop of the world was reported by the United States Department of Agriculture as follows, showing this country to be by far the largest grower of wheat in the world:

Countries.	Bushels.	Countries.	Bushels.	Countries.	Bushels.
United States . . .	670,063,000	Italy	131,102,000	Egypt	12,000,000
Canada	98,654,000	Spain	123,440,000	Algeria	27,000,000
Argentina	56,380,000	France	352,716,000	Australasia	43,927,000
Chile	12,000,000	Germany	143,315,000	Mexico	12,403,000
Austria	49,655,000	Belgium	14,228,000	Russia in Asia . .	81,693,000
Hungary	168,899,000	Great Britain . . .	60,065,000	Turkey in Asia . .	35,000,000
Roumania	76,220,000	Portugal	10,400,000	Other countries . .	97,291,000
Turkey in Europe	25,000,000	Russia in Europe .	597,014,000		
Bulgaria	32,000,000	British India . . .	224,335,000	The world . . .	3,124,422,000

Of late years there has been some tendency towards reducing the area of individual large farms, and very probably some of those previously mentioned may be reduced before this reaches the reader. The sections that are most likely to remain as large farms operated for single crops are those which in their natural state possess qualities of soil adapting them specially to the growth of wheat or other cereals.

The great wheat farms of Minnesota and North and South Dakota are not usually fertilized except by the process of fallowing. In the case of the cultivated wheat farms rotation of crops is not practical, because of the limited amount of rainfall.

In 1900 there were 290,724 persons engaged in agricultural occupations in the United States, or a little more than eleven per cent. of the working population. The majority of this farming population is located on the small farms, the work on the large farms being performed with a comparatively small number of men. The figures showing the growth in number of farming machines and tools are startling. In 1840 there were but three reapers made; by 1850 the number had increased to 3000, and by 1880 to 60,000, while the total in use in 1904 is figured at two and a half millions.

Some idea of the immense volume of American agricultural industry may be gathered from the following list of implements manufactured in the country during that year, the list including only those of which more than a hundred thousand were made, and excluding such small tools as hoes (of which three and a third

million were manufactured) and snaths (of which over half a million were made): corn-planters, 208,000; cultivators, 502,000; harrows, 300,000; shovel-plows, 102,000; sulky-plows, 136,000: old-fashioned plows, 819,000; harvesters and binders, 233,000; horse hay-forks, 620,000; horse hay-rakes, 216,000; mowers, 398,000; and corn-shellers, 106,000.

The amount of hand labor now required to produce a bushel of wheat is only ten minutes, valued at three and a third cents; in 1830 it was three hours and ten minutes, the cost being seventeen and three-quarter cents.

A comparison drawn between the manual labor required on a ton of hay in 1860, when there was no improved machinery, and 1894, after the mower, hay-tedder, and hay-rake came in, shows that in the former case the hours of hand labor were thirty-five and a half, valued at $1.29, and in the latter eleven hours and thirty-four minutes, valued at $3.06.

If the farmers of the United States should raise crops of the present size by the old methods of fifty years ago, the increased cost of the corn crop each year would be $523,000,000; of wheat, $79,000,000; of oats, $53,000,000; and of hay, $10,000,000. The introduction of the automatic cord-binder was the cause of the great demand for harvesting machines, which began in the early eighties. The largest manufacturer in the country of harvesting machinery makes in a single year 75,000 self-binding harvesters, more than 100,000 mowers, 9000 corn harvesters, 10,000 reapers, and 75,000 horse hay-rakes.

On the large level farms of the great West plowing is never done with a single horse and plow, as in the East, but the plows are set in gangs and driven by great traction steam-engines. When the field is fairly well softened the wheat plowing can be done with gangs of rotary plows, these having cupped disks set at an angle and weighted so as to sink into the soil, as shown in the illustration. The use of the traction engine instead of horse-power renders possible the employment of reapers and harvesters of great size with cutting power of unusual strength.

The machines employed are as far as possible arranged in combination, so that the labor of a few men may accomplish a great deal of work. For instance, a traction engine may be arranged to draw a line of plows, while hitched immediately in the rear is a row of harrows, and behind these are a drill for sowing the seed and rakes for covering it. In the reaping operation the traction engine draws mechanism that not only heads the wheat, but also

threshes it, cleans it, and puts it into sacks at a single continuous operation.

On the Western wheat farms the straw is usually burned in the field, this being necessary because it cannot be plowed under and absorbed by the light soil, which lacks moisture. The burning saves the ash as an aid to fertilization, although the nitrogen is lost.

The United States produces more wheat than is required for home demands; so do Russia, Hungary, Roumania, Bulgaria, and Servia. Our wheat fields, therefore, not only supply the principal

A Six-Disk Steam-Plow at Work.

item of food for the Eastern States, but also furnish a share for the countries that have to buy, which are principally Great Britain, France, Germany, Austria, and Italy. Russia might be as great a wheat-producing country as the United States, and probably will be within another generation; but the slow development of railways there and the general lack of enterprise keep her behind us in agricultural development. The time will come, however, when Russia will have the advantage in competing with us in feeding the countries named, with the possible exception of Great Britain. For the year ending June 30, 1903, we exported 114,181,420 bushels of wheat and 19,716,484 barrels of wheat flour.

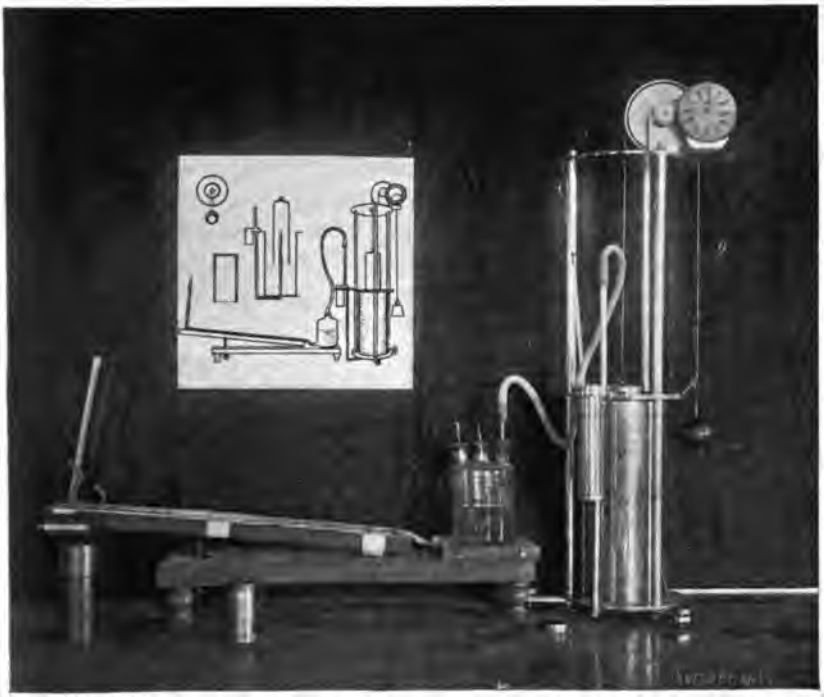
The development of American farming is very much owing to the wise expenditures of the government in the maintenance of an Agricultural Department, and various agricultural colleges and stations for scientific study of the problems that confront the tiller of the soil. Some fifty-five million dollars have been invested in buildings, apparatus, machinery, libraries, and equipment for these institutions, which have a total income of over six million dollars a year. Our agricultural colleges now contain over 30,000 students, of whom over 4000 take special courses in agriculture.

In breeding plants the most recent theory is to discard novelty and to seek to increase the efficiency of the special plant under experiment; as, for instance, in the case of corn, the endeavor would be to cross varieties in a way to strengthen resistance to drought or to increase its starch contents. It is not the beautiful form of an ear of corn that determines the value of a variety so much as its food quality and its resistance to disease. Formerly it would have been considered valuable to produce a variety of string-bean with a beautifully formed pod having very little string; but according to the latest ideas the pod is of very little importance, and the point sought in trying to produce a better string-bean is to secure the fullest amount of protein in the bean and to have a plant that will do well in dry seasons. This theory of progress, which is making some advancement, is calculated to do away with the notion that new varieties are desirable. It is the general improvement of a special plant that is aimed at, rather than the production of a special variety. This sort of education comes from the agricultural schools, whereas the growth and spread of the variety idea came from individuals who sought to make money out of a special plant they could control.

The Bureau of Soils connected with the United States Department of Agriculture has recently issued a pamphlet containing the results of an exhaustive investigation of the chemistry of soils with a view to judging of their suitability to raising certain crops. The members of the bureau have evidently expended a great amount of intelligent thought and labor on this problem, and their conclusion is that the chemical examination of the soil is of little value as tending to show the probable yield of a crop. The fertility of the soil is demonstrated to be due mainly to the supply of water and plant food; if the proper food is there, and the moisture is supplied to bring it into solution, so that the plants can use it, the crop will be benefited; but if there is a lack of proper plant food, or a lack of necessary moisture, the yield must necessarily be

restricted. The conclusions of the bureau are simple, and have been held as theories by intelligent farmers, but now have been practically demonstrated and worked out with great pains as the result of a long series of experiments.

The earlier work of the agricultural societies lay in the analyses of soils and fertilizers. In this way the value of commercial artificial fertilizers and the needs of particular soils were determined, and published for the benefit of farmers interested. It



Courtesy Scientific American.

Apparatus for Studying Soil-Grains.

may be interesting to describe the most recent apparatus for determining the effective size of soil-grains. It has a receptacle for water, an aspirator from whose bell a tube leads to an air-chamber, and a soil-tube closed at one end and covered with wire gauze at the other; an air meter is used with this and a pressure gauge. With this apparatus any specific soil may be examined and tested as to its qualities for holding moisture and for the solution of plant foods.

For the work of our agricultural stations there have been developed groups of scientific experts to take up the different problems from such view-points as chemistry, botany, physics, zoölogy,

agronomy, horticulture, forestry, entomology, etc. The students of the last-named science have made extensive researches in regard to beneficial and injurious insects, and one institution in Ohio has a collection of about 4000 insects that have been reared and studied at that station.

The study of new varieties of crops has resulted in a number of successes, and most noteworthy among them is that of importing the Australian saltbush. This was originally sought in order to redeem the semi-arid lands of the West, and it was found that it rendered available for grazing thousands of acres that were previously considered worthless. Incidentally its culture led to the discovery that all upland soils in arid climates contain from 2000 to 4000 pounds of alkali per acre, although there is usually no visible indication of it.

In testing varieties of small fruits and vegetables, and in studying practical methods of improving them, the agricultural stations have aided greatly in building up horticultural science. The work of the experts and students at the stations is very largely added to by the thousands of co-operative agricultural experiments undertaken by farmers who are interested in the work of the stations. The agricultural stations furnish plans of work for these, and all the seeds, fertilizers, fungicides and other materials required, and also assist the farmer with any required data as to the nature of his soil and what it may require. In return for this the farmer usually gives the use of land and labor, which is of benefit to the station.

The dairy farmers have received a great deal of assistance from the agricultural department; the constituents of milk having undergone a great deal of study; also methods of feeding cows and determining the amount of fat and other ingredients of the milk, the investigation having also extended into the dangers of milk infection, as in the case of tuberculous cows, and effective work has been done along the lines of pasteurization as well as in methods of sterilization. The use of cultures in butter-making and cheese-making, as undertaken in the ripening of cheese, have also furnished fertile fields of work.

As our population increases it is evident that there must be a curtailment of the land now devoted to grazing animals. The cattle range is located where the land is of trifling value, but as values increase it is necessary to confine animals to smaller areas. The agricultural stations have proven that a farm animal can be kept on about one-tenth of the land used in cattle ranges, by correct

methods of preserving herbage for its use. Green cattle foods can be preserved, by the use of the silo, in a state that is almost as valuable for future consumption as at the time they are cut. The stalks of Indian corn and sorghum and other green forage crops are all nutritious and good to be used as cattle foods if they are properly intermixed with other foods.

When it comes to the question of feeding the greater population that will occupy our land fifty or one hundred years to come, the agricultural student meets the point by demonstrating that whereas the present average yield of wheat to the acre in the United States is about thirteen bushels, and that of Indian corn about twenty-seven bushels, with proper attention to feeding the soil scientifically, the production of wheat can be increased three or four times, while that of Indian corn can be considerably more than doubled.

The trucking business is a modern development of what was formerly termed market gardening. The modern trucker undertakes to raise fruits and vegetables to supply the market in some great centre during the entire year. There has been a steady growth in this branch of the farming industry, owing to the demand of cities for a better and more varied supply of food, and to the increased facilities for transportation and preservation. It has become of such commercial importance that in some localities whole blocks are devoted entirely to the produce business, and men of means and ability engage in it, whereas it was formerly followed mainly by men of humble aspirations. To the truck-farmer we owe the methods that have been termed " intensive" farming, by which a single acre is sometimes made to yield a $500 crop, and is cultivated and cared for like the flowers in a hot-house. He knows how to keep in close touch with the agricultural colleges and experiment stations, and is ever the first to grasp a new thing in seeds or buy a new fertilizer.

In the vicinity of all the great cities of the country the truck-farmer flourishes, mostly sending his produce to a commission merchant, who handles it on a ten per cent. basis, though some of the more clever secure direct trade with the hotels and other large buyers. While the bulk of shipments are from the South, where the temperature is mild, to the cities of the North, where fruit and vegetables do not ripen so soon, yet there is considerable trade in the other direction. For instance, New York City secures nearly all her late fruits from the small-fruit section up the Hudson River, centring between Newburgh and Poughkeepsie, and northern-

grown potatoes, cabbages, onions, and celery are sold in the South every winter.

For reasons which it is hard to fathom, certain articles of produce have tended to centre in certain sections. Crystal Springs, Mississippi, is the greatest tomato-shipping point in the world; Kalamazoo, Michigan, is famous for its celery; Marlborough, New York, is the place for raspberries; and Rocky Ford, Colorado, for cantaloupes.

Water transportation is favored by all truckers, not so much because the rates are apt to be lower than by rail, as because the produce, especially fruit, tomatoes, etc., is apt to arrive in much better condition, being subjected to fewer jars. The railroads

The Ivel Agricultural Motor.

have learned to cater to the trade, however, and on many lines there are now well-ventilated fruit-cars, with springs and air-brakes like a passenger-coach, and in some instances these cars are sent through at express speeds, so that the fruit may arrive promptly and in good condition. With such conveniences, perishable and delicate fruits may commonly be shipped for distances not exceeding a forty-eight-hour run, although in either very hot, very rainy, or very dusty weather the fruit is liable to serious depreciation from such a journey. Refrigerator transportation is now coming more and more into use for fruits, having been so successful in the transportation of meats.

In 1637 there were thirty-seven plows in the whole colony in the vicinity of Massachusetts Bay. Those who owned them either

did the plowing for their neighbors or loaned the plows when not in use. A great deal of the land was tilled with hoes and mattocks. This condition of affairs did not change much in the next hundred years, and it was not until 1797 that the first cast-iron plow was made. This was patented by Charles Newbold, of New Jersey; but so slow were the farmers of that time to recognize an improvement that he did not live to see many of them in use. It was forty years after the date of his patent that the first of these plows was used in New Hampshire, the farmers objecting to it on the theory that it might poison the land. But after 1840 iron plows began to come in use with some degree of rapidity. The Oliver chilled plow, which came out in 1870, had a great run, and was followed in later years by the sulky-plow, which relieves the farmer of a great portion of the hard work in plowing. These plows are now made adjustable for wide or narrow furrows, and the share can be raised from the ground by a power lift, so as to pass over a large stone, and can then be reset by a foot-lever.

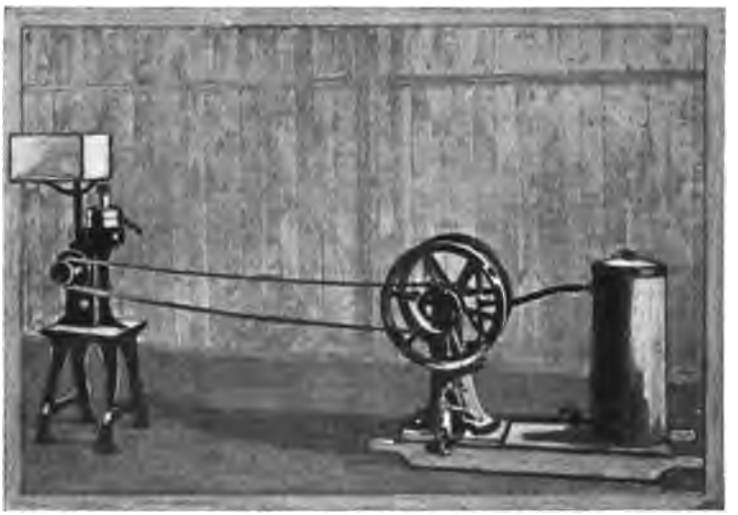
The early harrows were mere home-made wooden frames carrying a lot of wooden pegs for scratching the ground. Now we have the pulverizing harrow, clod-crusher and leveller, combined in one machine, which passes over a plowed field and reduces every lump of earth and sod to a given size, leaving everything level. The operator of this harrow sits in a comfortable seat, controlling it with the lever. The disk type of harrow is also common.

The minor machines for the use of the farmer have become very numerous. There is not a kind of seed that has not a planting machine adapted to sowing it, and which can be relied upon to distribute the proper quantity, and not to sow more thickly in one place than another, not only economizing seed but doing the work much more evenly than it could possibly be done by hand. The broadcast seeder is used for grain and grass, being attached to an ordinary wagon. All the intelligence required for its operation is that the hopper shall be kept full and the wagon driven over the land. In addition to doing the work of seeding, some of these machines can be used to distribute dry commercial fertilizers.

For such grains as require to be planted systematically in rows or hills, there is manufactured a grain-drill that can be adjusted to put the grain just where it is wanted; this machine is provided with a system of hoes for covering the seed planted by a straight or zigzag movement. Another form of grain-drill can be used also as a weeder. Yet another planting-machine is designed for drilling holes for beans, which are dropped in to the proper number

and covered, while the machine marks the correct distance for the next hole. This wonderful little machine can be arranged to plant alternate rows of corn and beans and also to distribute fertilizer, working it into the soil.

The latest form of potato-planter really seems to be capable of thinking. It picks up the potatoes and sorts them over, cutting them into the desired number of parts, separating the eyes and removing the seed-ends. It can be arranged to plant either whole or parts of potatoes at any reasonable distance from hill to hill. It drops the potato, throws in the proper amount of fertilizer, piles the earth over it in a little hill, and marks off the place for the next



The Gas Engine on the Farm (operating a Cream Separator).

hill. For the purpose of starting tender vegetables, as celery, lettuce, cauliflower, tomatoes, etc., in cold frames, for transplanting, there is a plant-seeder machine, which picks up the tender sprouts with the utmost care, and settles them in the earth, which is gathered up around the roots as well as any human hand could do it; then adding a good sprinkle of water, in order that the plant may survive. Notwithstanding the delicacy of the work, this little machine is capable of covering five acres in a single day.

Cultivating machines have been highly developed and a farmer may now have one for each sort of crop. These are usually provided with a seat, so that the rider is as comfortable as in a buggy, while the machine rolls along, seeming instinctively to recognize

the difference between the weeds and crop plants, and passing by the latter carefully, while each weed is snatched rudely from the soil. The fact is that there are so many beautiful little machines for the farmer's use that the owner of a small farm has to be careful not to keep himself poor by buying machines to do his work.

Electricity has proven of some use to the farmer, there being manufactured a number of motors for driving threshing-machines, winnowing-machines and the like. At the agricultural institution of the University of Könisberg is a farm with an electric-power plant that is used for lighting and for supplying power to the pump, saw, threshing-machines, cream-separators, etc. Its most curious use is supplying power for the driving of the electric plow, which work may be regarded more as an experiment than of practical utility. The main product of this farm is flaxseed, and the crushing of the seed is done economically by an electrically driven crusher. The electric plant is operated at small cost by means of a turbine, drawing power from a river that flows by the farm.

What may be expected in the future of mowing-machines is indicated by an auto-mower that has been manufactured by the McCormick concern. This may be described as a combination of automobile and mowing-machine. The ten horse-power gasolene engine that furnishes the power is provided with double cylinders, a chain and sprocket conveying the power to the driving-wheel in such a manner that the machine can either be run backward or forward. The power is transmitted to the cutting-blade by gears operating through a friction-clutch, and the steering is done by a crank connected with the guide-wheel in front of the cutter-bar.

In this connection it is interesting to note that the farmers of Central Michigan secure telephone service at the moderate cost of $3 per year, which would indicate that they are better financiers than some users of the telephone in cities. Their farm telephoning grew out of the building of a private line five miles long at Horton, Michigan, a number of local residents contributing towards the expense. This system grew because neighboring farmers desired to connect with it, and the expense of maintaining central stations was avoided by making use of the local mills, or some country store, where they were glad to do the work of connecting the subscribers for the use of the telephone free, and the business which came to them through being a telephone centre. This system is extended through a large number of Michigan towns, the original owners, now stockholders, receiving the service for $3 a year, and charging outsiders a $15 fee for coming in. This

system is so cheap and satisfactory that it would seem to require only to be started in any farm community to become a permanent success.

Taken altogether the farming business of the United States is in a more healthy condition that it has even been, and the methods are in advance of those employed in any other country. While

Courtesy Electrical World and Engineer.

A Telephone Dissected.

very many of the holders of small farms are not in a prosperous condition, because of the competition of those who operate large farms with modern machinery, yet the business is as good on an average as any other in which there is general competition. If the farmer has less cash than the merchant or manufacturer, he has compensation in living an out-door life that is more natural, and which makes his physical condition usually superior to that of the man in the city.

THE IRON HORSE AND THE RAILWAYS

To railways the United States is largely indebted for its commanding position as a commercial nation. We were the first to realize the enormous advantages of railways, and we built more and faster than any of the old countries of Europe. The railways enabled us to trade with each other; the facilities for trade resulted in the development of large manufacturing industries, and when these had completely stocked our own markets, they began to compete for the trade of other countries, and secured a leading share.

All this we owe in large measure to the railways. The iron horse of Stevenson has never been dethroned, only developed, and the locomotive of to-day is vastly more powerful than in its early history, and handles freight traffic at an exceedingly small cost. Notwithstanding all the scandal that has attended the financing of railways, the watering of stock, the gutting of treasuries, the receiverships, and kindred evils, the railways have been an enormous and inestimable benefit to the country, and have developed great stretches of territory that would be not one-tenth populated without them; and infant industries, born under their procreative power, have grown to giant corporations and trusts.

There has been talk in the United States about the decay of steam railroads, because the track mileage does not grow as fast as it used to; but it must be remembered, having within a generation covered the immediate needs of the inhabitants, that thousands more miles of tracks are not needed except for the gradual increase in trade and population. Then the trolley has been pointed out as foreshadowing the doom of the steam roads. The trolley is but another form of railway, and it matters not if electric propulsion shall in time largely take the place of the steam locomotive, the railways will still be doing their work. The automobile has been cited as another invention that would sweep aside the railways, but it will do nothing of the sort. The auto is simply a locomotive made to run on a roadway instead of a railway, and it can never carry freight with half the economy that it can be carried on rails. The railway locomotive may profit by imitating some of the good points of the auto, but will never be displaced by it.

Over against all that has been written in bitter and sweeping denunciation of railroads as greedy and selfish monopolies, sucking

the life-blood of the people, might be set not one volume, but many, showing what large and important factors the railroads of the world have been in bringing light into the dark places of the earth, subduing the forces of savagery and heathendom, converting deserts and wildernesses into blossoming gardens, developing resources of wealth and prosperity, and giving all life a new and larger hope and a wider range of activities.

The railways are here, and here they are likely to stay for generations to come; but they are subject to change, and, unless the writer is mistaken, methods of train-hauling will be subject to great and important alterations within a few decades. The freight service

A Baldwin Electric Locomotive.

will remain much as it is, going on to gradually heavier road-beds and using larger locomotives hauling heavier trains; but in passenger service there will be radical improvements and marked increase in speed. Discussing this topic in 1895, the writer said, of a railway projected to operate at a speed of 120 miles an hour, " The whole plan is so entirely practical that it is only a matter of time when such roads will be established between all important points." It is perhaps pardonable to revert thus to one's own prophecies when their realization is imminent. The ingenious men who figured out the practicability of such railway speeds a decade ago have been sowing seed and making converts to their theories, and the public is now largely aroused to the advantages of such rapid transit, and in Germany, England, and America there are movements in

progress that are sure to give the public this high-speed service before another ten years has elapsed.

What are known as the Berlin-Zossen experiments have been the most successful up to this time. Early in 1902 an alternating-current locomotive, designed by Herr Walter Reichel, attained a

Berlin-Zossen Electric Railway, Illustrating Track and Interior of Car.

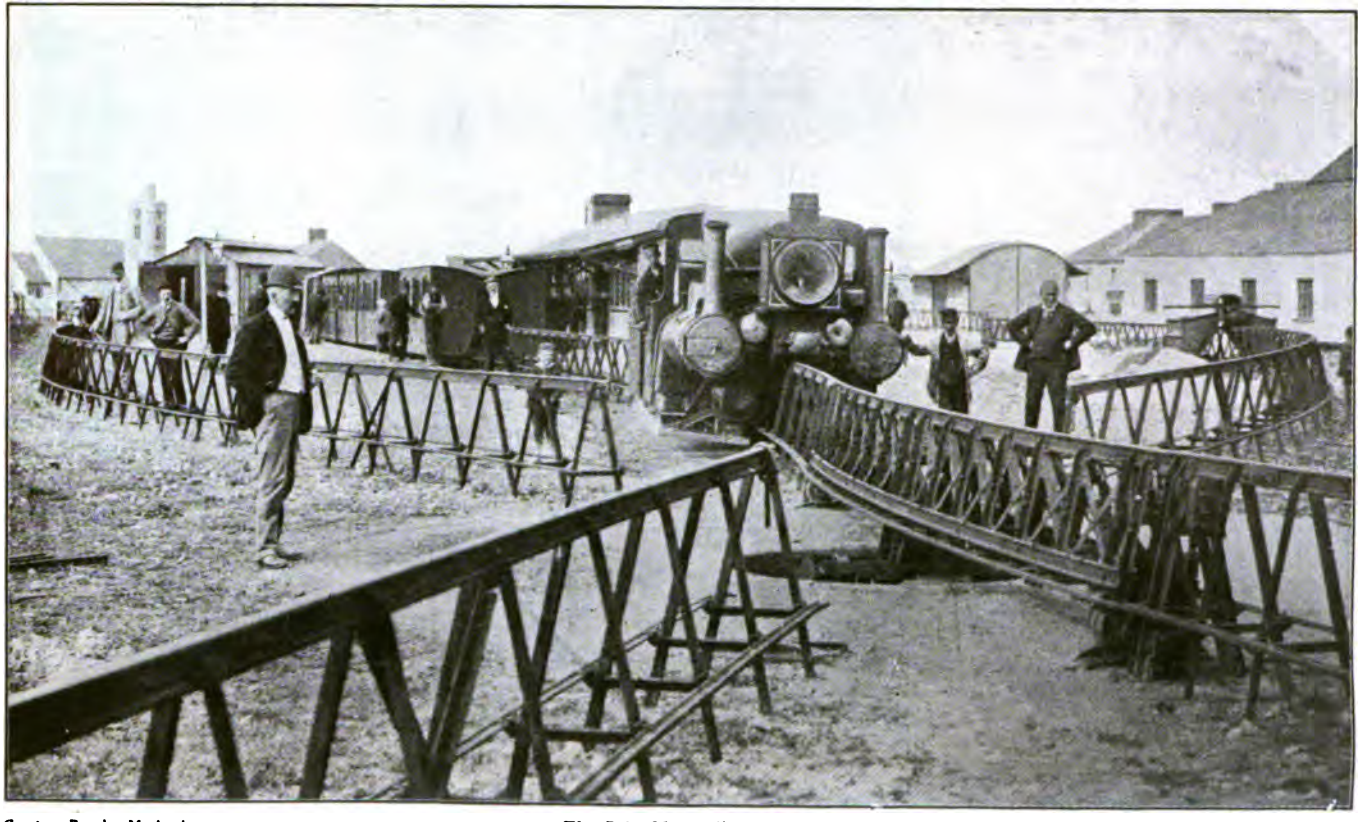
speed of 99½ miles an hour at one of the tests. This was accomplished with a 96-ton car. The Prussian state railroads held out inducements to locomotive builders that interested them in these tests, and it was arranged that a number of new designs of steam locomotives, and also electric locomotives, should be constructed in

order to secure still better results. From time to time we have received reports of yet greater and greater speeds at these tests, the 125-mile-an-hour notch being passed in the summer of 1903, and a little later 130 being attained. The engineers in charge of these experiments speak confidently of making 140 miles an hour before long in a speed test, though not recommending the operating of trains at an enduring speed of more than ninety-three miles an hour. The 125-mile speed was made with a car equipped with Siemens-Halske electric motors, there being four on the car, giving a total horse-power of a little over 1000. The current supplied was between 13,000 and 14,000 voltage.

Stimulated by such reports from Germany, the English parliament has recently authorized the construction of a monorail road on the Behr system, between Manchester and Liverpool, designed for speeds of 110 miles an hour. A London newspaper states that the money required to build the line, $300,000, has all been subscribed; but probably this is only the first instalment of expense, unless they have some cheaper method of railroad building than is known here. The Behr system consists of a single rail set on a trestle work about four feet above the ordinary ground level. As the cars straddle this rail, the seats coming down below its level on either side, running off the track is impossible. There are guard-rails on the lower sides of the trestle, against which small wheels of the car bear, in order to secure an upright position or the proper inclination in rounding a curve.

The top rails are of heavy steel, similar to those used on ordinary steam roads. The ground ties are of steel, set in cement and rock ballast. Electric motors are used to drive the wheels, all supporting wheels being " drivers." The passenger cars are of four tons' weight and sixty feet long, seating thirty-two persons. The running time between Manchester and Liverpool, thirty-four miles, will be twenty minutes. A double-track line is built, so that trains will run simultaneously in both directions, carrying passengers, mail, and light parcels only.

America, I am sorry to say, is a little behind in this competition in great speeds; still, we have a monorail system, a company incorporated to back it, with franchises granted from Washington, D. C., through Baltimore, to Gettysburg. A small experimental line has been operated successfully at Baltimore, and work is to be begun on the main line at once. This road could run its cars 100 or more miles in an hour, were it not that it will have but eighty-five miles of track, which it is expected will be traversed within an hour,



Courtesy Popular Mechanics.

The Behr Monorail System.

including stoppages. The inventor of this American monorail system is Howard H. Tunis, of Baltimore, and he plans to run single cars for passengers only, these being fifty feet long and five feet wide, seating thirty-two persons. The track consists of ties supporting a single rail, such as is used on ordinary steam railways, only it is placed in the centre of the ties. About eleven feet above the ground is a superstructure having two side rails formed of 2 x 3 inch angle irons, within which run a set of wheels attached to the top of the car, and designed to maintain the car in position on the lower rail.

The Baltimore-Washington Monorail System.

Those interested in the Tunis system believe it has a great future for elevated roads, especially for a superstructure above an existing road, to carry the express traffic. Its greatest advantage over a two-rail system is, of course, its ability to go around curves without reducing speed. So long ago as 1880 Captain J. V. Meigs, of Boston, claimed to have made a speed of over 100 miles an hour over a short distance on a "saddleback" single-rail experimental road; but the public was not ready for it, and it never came into use. Similar was the history of the Boynton road, built experimentally near Coney Island, and of the Brott system, projected in Washington, D. C., in 1895.

It is very doubtful whether a speed of 100 miles an hour was ever attained by a steam locomotive, though newspapers have published accounts of even greater speed records. The Empire State express has been credited with a mile at the rate of 112.5 an hour, but record miles made by counting telegraph poles, or noting mile-

posts, by the watch of some one anxious to make a record, are untrustworthy, as shown by the results of well-authenticated tests. A train on the Lake Shore and Michigan Southern Railroad was given a speed test some years ago by competent officials, making the run between Chicago and Buffalo at an average speed of 72.92 miles an hour. The best mile of the run was made at 92.3 miles an hour and the best eight miles at 85.44. All this was accomplished under the most favorable conditions, with a train-load of 304,500 pounds. A similar test was made on the Pennsylvania Railroad in 1903. A 25-mile stretch of track was cleared, this being in exceptionally fine condition, and slightly down grade, while at the lower end was a mile of straight and absolutely level track.

Modern Baldwin Passenger Locomotive.

This mile was accurately measured, and electric circuit-breakers placed at the end of the mile, with the most accurate and reliable recording apparatus, so as to leave no dependence upon the fallibility of some individual. The down-grade run was first made with eight coaches, then seven, then six, and so on, the speed increasing as the coaches were dropped. On the last trial the engine alone, the best on the Pennsylvania road, came thundering down the grade, with every ounce of steam that a skilful engineer could crowd on, yet the best she could do was to cover the mile on the level track at the rate of 95.1 miles an hour. Until this record is beaten by another where there are similar precautions to secure accuracy, we are justified in disbelieving the stories as to steam locomotives covering more than 100 miles in an hour, even on down

grades. The electrically driven cars can make higher speeds because there are no reciprocating parts, as in a steam locomotive. Yet before such speeds as 100 or 125 miles an hour are made as a matter of every-day travel, tracks and road-beds will require to be rebuilt on much improved lines. Two of the worst railway accidents of 1903 happened through the efforts of engineers new to the roads trying to make speed on curves, and the trains jumping the track by centrifugal force. Heavier rails, straighter curves, and increased elevation of the outer track on curves are essential to higher speeds.

The locomotive of Richard Trevithick, of Cornwall, built in 1803, weighed five tons, and could pull about ten tons of freight at a speed of five miles an hour. It was too heavy for the light rails on which it was run, and, although on one occasion it made

144-Ton American Freight Locomotive.

sixteen miles in an hour running light, it was abandoned, and Stevenson's name has come down to us as the builder of the first successful locomotive. Just 100 years after Trevithick's effort the Baldwin works of Philadelphia turned out a freight locomotive for the Atchison, Topeka, and Santa Fé road that weighed nearly 144 tons, being thirty-six feet over all, exclusive of the tender. This is of the compound decapod type, having ten driving-wheels and four truck-wheels. The firebox with the tubes has a heating surface of nearly 5000 square feet, giving enormous steam-making ability. The drawbar pull or tractive effort of this great freight locomotive is nearly 40,000 pounds, as against 500 for its forerunner of 100 years earlier.

The record of railway development is an impressive one. It began in America with the building of the " Best Friend," the first American locomotive to see commercial service. This was built at West Point in 1830, and used on the South Carolina railway.

It was a four-and-a-half-ton affair, and made twenty miles an hour ordinarily, and could make thirty-five running light. The Charlestown and New Hamburg line, on which it was operated, was 137 miles long, and for many years the longest in the world. It was not until after the war of 1861–5 that any American railway had 1000 or more miles of tracks.

About 1875 America was credited with more than half the railway mileage of the world; but we have built slower since, and other countries faster, so that of the something over half a million miles of steam railway now operated on the globe, the United States has but 200,000, this figure not including second tracks or sidings, nor the 17,000 miles of electric or trolley lines. The official figures for the different continents in 1901 are: Europe, 180,708; Asia, 41,814; Africa, 14,187; North America, 226,503; South America, 33,067; Australia, 15,649. The mileage added in 1900 was 10,798, and in 1901 16,947, and with long lines building in Asia, British America, South America, and Africa, these figures may be exceeded for some years to come.

The railways of the United States are capitalized at over $13,000,000,000, half being in stocks and half in bonds, and about half of the stock paying dividends. If this is over-capitalization, the condition in Great Britain is much worse, for their roads are capitalized at $260,000 per mile, which is more than four times our figure, based on mileage. However, their roads are better protected than ours, with better fencing, heavier ballast, and fewer grade crossings. We kill on American roads eight yearly where the British roads kill one. The average Englishman rides four times on the railway where the American rides once, but the American rides farther. The United States has two and a half miles of railway to each one thousand of population while Europe has only .44 mile to the same population. In America the railway companies think much more of their freight traffic than of the passenger service, as most of the money is made in hauling freight. While this is also true in Europe, yet the proportion there is more favorable to consideration of passengers.

The freight business of the railways of the world is so large as to make the figures incomprehensible. In 1901 the ton-mileage —that is, the number of tons hauled one mile—was 147,077,136,040, a figure calculated to make even an astronomer gasp. The popular impression would be that the crops and manufactures furnish the bulk of the freight carried, but such is not the case. The mines furnish about half, owing to the great quantity of ore hauled in

some regions, the forests furnish one-eighth, farms one-ninth, and factories but one-seventh.

The railways of the United States have in use 25,000,000 tons of steel rails. If solidified into a mass they would exceed in dimensions the Great Pyramid of Egypt, while the wooden ties would equal twenty-four pyramids, and the ballast 135 more. There are now (1904) 40,000 locomotives in use on American railways, and

Courtesy Goodwin Car Company.

Ballasting a Railway Embankment.

almost as many passenger, mail, and baggage cars, while the freight cars total one and a half million, and if arranged in lines between New York and San Francisco would cover the distance six times. The employees required to operate these number about 1,100,000, of whom over forty per cent. are trackmen and laborers.

The American custom is to use about one-fourth more ties in track-laying than is the rule in Great Britain and Europe. This may be partly owing to our heavier freights. On the other hand,

foreign roads are better ballasted and fenced in to a degree unknown here. The British practice is to place a cast-iron block, called a chair, between the rails and the ties. This is necessary owing to the softer wood used for ties, as the chairs secure a larger bearing surface on the wood. Overhead bridges at stations are compulsory in many other countries, even for small stations. The automatic block signals used here are considered superior to signalling systems of Europe, and are likely to come into use over there.

We often hear of express trains running sixty miles an hour, as though this were a common thing in railroading. The fact is that the fastest regular long-distance train in the world makes

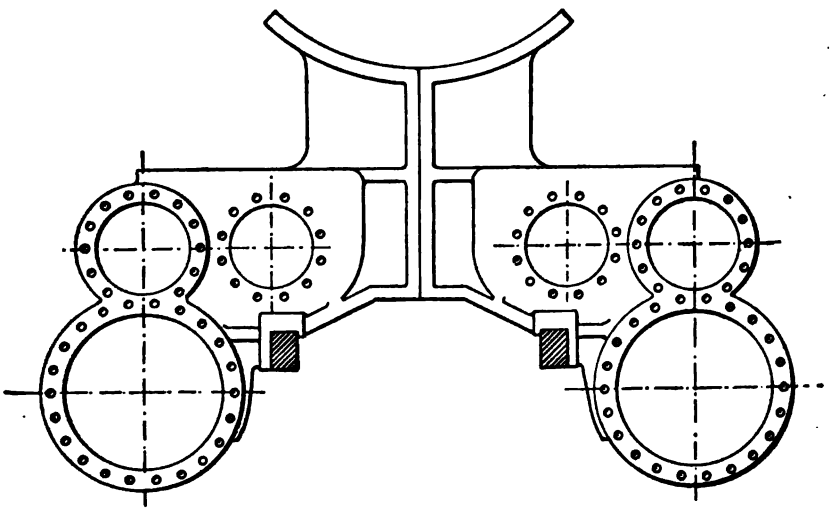


Diagram showing Common Arrangement of Cylinders in a Compound Locomotive.

an average sped of 54.2 miles an hour. This is on the Orleans and the Midi railways from Paris to Bayonne, the run being 486¼ miles, on lines not free from heavy grades and curves. The locomotives employed are compounded, that is, have two high- and two low-pressure cylinders, a heating surface of 1890 square feet, and a weight of fifty-four tons. The weight seems very small from an American view-point, but the steam pressure is high, being 213 pounds. The law limits the speed to 74.5 miles an hour, which is about ten miles less than these locomotives can make under favorable circumstances.

The fastest long-distance expresses in the United States are the twenty-hour limiteds of the Pennsylvania and New York Central roads, run from New York to Chicago. The distance in each

case being 980 miles, the average speed, it will be noted, is a trifle under fifty miles an hour. The trains are much heavier than those on the Orleans road, probably averaging nearly twice the weight, while the locomotives weigh 140 tons or more, or nearly three times the weight of the French engines. The American practice is to change the locomotives several times during each trip, giving each machine an average run of only 163 miles.

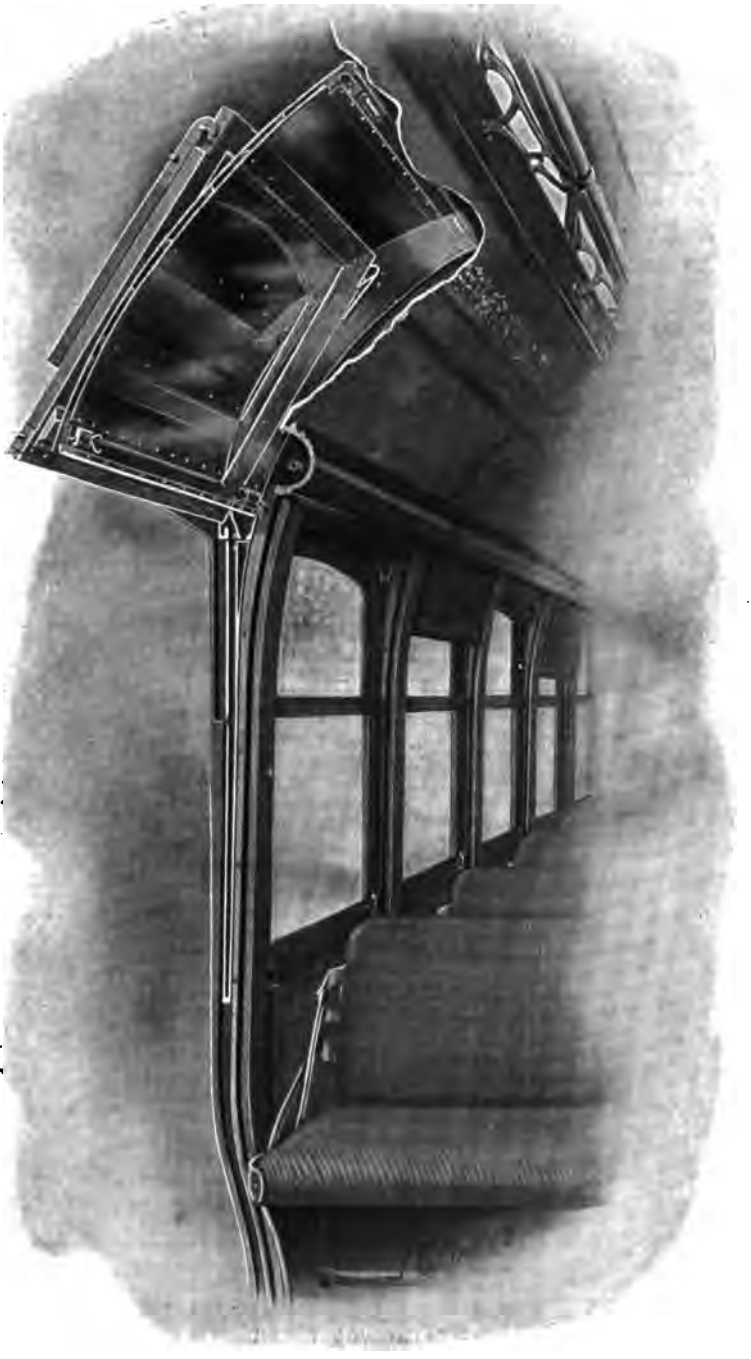
In making these fast regular runs, both the European and American locomotives are run at times at speeds up to about seventy-five miles an hour, as on almost every trip it is necessary to speed up somewhere to make up for delays at other points. Then the time of the stops has to be made up, as well as the slow-downs for curves. The loss of time on curves is not fully appreciable to the uninitiated. The train-wheels are constantly pushing against the outer side of the curve, causing enormous friction, and reducing the speed. It has been estimated that every degree of curvature is equally as hard for the train to overcome as a three per cent. rise in the grade, if the train be running fifteen miles an hour. With an express running sixty miles an hour it is much greater, how much nobody knows exactly.

For the comfort of the traveller by rail there seems to be no end of invention and improvements. One of these, just coming into use, for both electric and steam roads, is the convertible car, open in summer and closed in winter.

Within a few years there has been a marked increase in railway projects and railroad building for the purpose of developing vast regions not before open to trade. First came the great trans-Siberian railway, constructed by the Russians to give them a gateway to China and the Pacific. This has stimulated an American syndicate to make overtures to Russia for a franchise to connect Vladivostock with Cape Naniamo at Bering Strait, with a view to tunnelling the strait, and connecting with a projected line running through the Yukon territory to Canada and the United States. If these plans are carried out, there will be an all-rail route between the United States and Europe, and the time of a trip around the globe may be materially reduced.

A South American line is contemplated, which shall connect New York with Buenos Ayres. There is now in course of construction a transcontinental line from Rio Janeiro to Chile, and the Brazilian government is undertaking several minor railways. Thus is South America being opened up to trade.

The trans-Siberian railway, which has been building since 1892,



The Brill Convertible Car.

and which was not fully completed at the beginning of the Russo-Japanese war, has been much discussed. It will be the longest railway on the globe, extending over a stretch of 4740 miles. This tremendous undertaking will cost about $200,000,000, which seems a very small sum considering the length of the route. It should be borne in mind, however, that the greater part of the road is built for light traffic, with light rails and ties. There is no such heavy traffic as Americans are familiar with; before the war trains left Moscow for Irkutsch twice a week, and required nine days for a trip. What are known as trains de luxe, but which we in America would call a train of parlor-cars, were run once in ten days. The passenger cars are of good size and well lighted with electricity. One of the most difficult portions of the route is the crossing of Lake Baikal, which is frozen over during several months of the year. This lake is forty miles across, and steamer transportation is now employed, though a rail line is being laid around the lake a distance of several hundred miles. The boats used for crossing are patterned after the American ice-breaking boats used on Lake Michigan, and have three powerful screws, which enable them to cut through three and a half feet of ice at a speed of three knots an hour.

One of the Manchurian branches of the trans-Siberian road runs south to Port Arthur, there connecting with the new railways that are building in China. The first railway in the Flowery Kingdom was built in 1876 with British capital. It ran from Shanghai to Woosung, but has been gradually extended until it is now a 300-mile line from Peking to Port Arthur. The most important of the present railways of China is the Luh Han railway, controlled by a Belgian syndicate and joining Peking with Hankow. The latter is a great city at the junction of the Han River and Yang-tse-Kiang, and this railway forms a natural northern trunk line for China. The principal railway projected south of the Yang-tse-Kiang is the Yeun Han railway, connecting Wuchang with Canton. When this is completed there will be a through rail line from Hongkong, by way of Hankow, to Calais, Peking, and (by Port Arthur to Irkutsch), to Moscow and Europe.

Among the numerous minor railways projected in China is one from Canton to Samshuy, which is being built by the American-China Development Company with American capital. Canton has about the same population as New York City, and this company, whose field of work is commercial development in this thickly populated region, has laid out a railway about 750 miles long, that is to be completed in 1906. This will probably be the best-built rail-

way in China, as steel bridges and cement piers and abutments are being used throughout; while thirty-foot rails weighing twenty-five pounds to the foot are being laid, and ballasted to a depth of sixteen inches with broken stone. All the rolling stock is of American make and the locomotives used are to be of 130 tons; the signalling system is also to be patterned after that used on American roads.

Railway Tunnel and Embankment, Tomasopa Cañon, Mexico.

In Africa enormous railway projects are coming into being, and Cecil Rhodes's dream of railways clear across the dark continent will be realized before long. France, which holds possessions in Algiers, extending over the Sahara to the Ivory Coast and the French Kongo, is seriously contemplating the construction of a railway across the arid desert to connect these countries. The main line is to run from Biskra to Lake Tchad, a distance of about two thousand miles. At the same time the British in South Africa are displaying tremendous energy in railway building. The Biera-Salisbury line has been extended southward to join the railway at Bulawayo; from thence a line has been run to the Wankie coal-beds, crossing the Zambesi at Victoria Falls. The line is run thence northward to the Kongo border, and via Katanga to Lake Kasali, which is a thousand miles from Bulawayo. In order to supply the

missing link between the Egyptian railway and this South African line, a road is projected from Stanley Falls on the Upper Kongo to Mahagi on Lake Albert Nyanza. The consummation of these plans means an all-rail route from Cairo to Cape Town, and there is no reasonable room for doubt that they will be carried out, as the needed concessions have been obtained from both Great Britain and Belgium, which control the territory, and the work of building is progressing with great rapidity.

The development of railway lines in South Africa was seriously

Courtesy Scientific American.

Constructing an Elevated Railway.

hindered by the Boer War, but there is now strong activity manifested in the projecting and building of new lines. Up to 1902 about a thousand miles of railway had been built in the Transvaal and adjoining territory. The most important of these lines was the eastern line from Pretoria to Komati Poort, which is 295 miles in length; the main line from Pretoria to Pietersburg, 178 miles in length; the Southeastern line from Elsburg to the Natal Frontier, 160 miles in length; and the Southwestern line from Johannesburg to Klerksdorp, a distance of 117 miles. These roads are, as a rule, very well built, as the substantial bridges, piers, and embankments attest.

The British Government has in construction and approaching completion a railway from Johannesburg to Vereeniging, a distance of thirty-four miles, which is to cost $35,000 per mile. Concessions have been obtained or projects are on foot for nearly a thousand miles of other railways in South Africa, the longest being a line from Klerksdorp to Fourteen Streams, which will form a direct route to Cape Town and the western provinces.

The Cape railway service was improved by the addition of a train de luxe, which was shipped to Africa from England in October, 1901. This train comprised six coaches, each fifty-six feet in length, and included all of the comforts and luxuries to be found on the best Pullman cars in America or Europe. There is a dining-saloon, library, buffet, smoker, card-room, observation platform, kitchen and pantry, and arrangements for converting several of the coaches into either day parlor-cars or sleepers.

In addition to the above, Natal owned 518 miles of railway, costing nearly $40,000 per mile, in 1902, which has doubtless been considerably increased at the present date. At the close of 1899 the Cape Government system of railways reported a total operating mileage of 1990, built at a cost a little exceeding $1,000,000.

In Australia the extension of railways meets with considerable retardation because of the different gauges (or distance between rails) employed by the existing lines. However, efforts are on foot to standardize the gauge, and build a 1000-mile line, at an expense of $7,500,000, from Kalgoorlie in the Westralian goldfields to Port Augusta, which is now the western terminus of the South Australian system. Here, as elsewhere, the railways are first in demand for transporting ore and thus opening up the mineral wealth of the territory; later for carrying timber and agricultural and manufacturing products.

The cradle of history, the land of the Arabian Nights, is also opening up to the civilization of the locomotive. A German company is constructing what is known as the Bagdad railway, which is to form part of a system connecting Europe with India. The present line crosses Asiatic Turkey, uniting the Bosphorus with Persia. One branch is to go to Konia, the holy city of Asia Minor, another branch to Angora. The Bagdad line runs from Angora, along the Tigris, past the site of ancient Nineveh, through Bagdad. The Euphrates is crossed at the ruins of Babylon, and thence the road is projected to the Persian Gulf, stopping at Mohamera.

The railways of India now reach to the limits of British territory in three main lines, one of which extends into Indo-China,

and in 1902 the first trains were run from the Caspian Sea to the Pamirs, across the desert sands of Turkestan.

Thus is the Old World emulating the New, and ere the first ten years of the century have been swept into oblivion, all the old continents will have been opened up to civilizing trade, just as the great West of the United States was opened up by the Union Pacific road. There is no civilizer like the railway. It means cheap trans-

Goodwin Self-Dumping Cars Unloading on a Trestle.

portation, and this means an exchange of goods, and wider intercourse, and mixing of peoples, by which all may profit.

For the great cities of the world the railway is doing as much as for the corners of the earth. In New York we have the Rapid Transit Subway, built at a cost of $35,000,000, to give additional facilities for up and down town travel in the metropolis. Manhattan Island is tunnelled from South Ferry to the Harlem River, and it is only a matter of time when Borough Hall in Brooklyn

shall be joined to the system by a tunnel under East River. The Pennsylvania Railroad has brought its terminal directly into the heart of the upper part of the city, coming in by tunnels from New Jersey and going out by tunnels to Long Island. The company is probably spending as many millions on these improvements as have been spent on the subway. Not to be left behind in the march of progress, the New York Central Railroad is altering and improving its terminal facilities at the Grand Central station on an enormous scale, and this terminus, together with the Pennsylvania's terminal stations in New York and Philadelphia and the Boston terminal station, must be classed as the finest of the sort in the world.

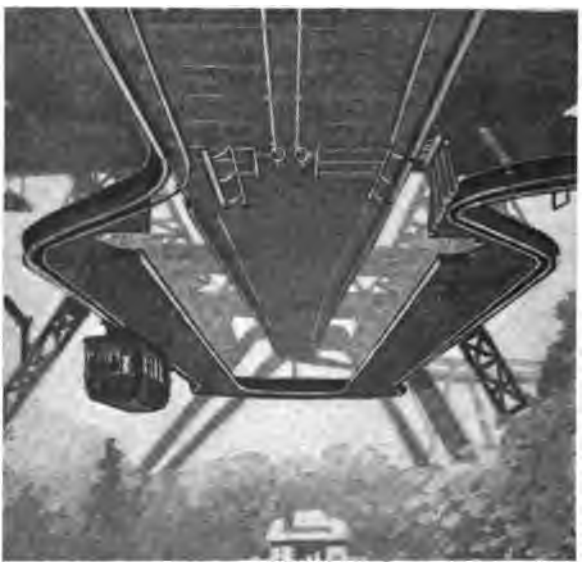
Elevated Electric Railway at 110th Street, New York.

The electrification of the elevated roads of Greater New York, though interfering somewhat with the service at the time of change and while the machinery was being smoothed up, has proven a great advantage in ridding the city streets of the smoke-producing locomotive. Why the authorities did not insist on the covering of the third rail, permitting the power to be taken from the side, is a mystery to the writer. There is nothing very difficult mechanically about such an arrangement, and it would have been a great protection to life, as, though elevated, the charged rail is so placed that a greater or less number of persons are sure to fall upon it. But this is in keeping with the American custom of saving money in railway equipments at the expense of human lives, and not even the large damage verdicts rendered by juries against the companies

after every fatality seem to have much influence in correcting the evil. We need the sort of legislation that prevails in Great Britain before our railways will cease to kill and maim.

The London underground railways are being supplied with electric motive power, the new trains being very similar to those of the Boston elevated railway. Positive and negative rails are employed, and whether the system is safer for the public than the third rail system of New York remains to be demonstrated. In making up trains, motor-cars and trailers are run alternately, as in New York and Boston.

An invention that may serve to hasten the electrification of steam roads is that of E. W. Farnham, former superintendent of the Burlington Railroad, near Chicago. He has developed a system in which the third rail carrying the electric current is "dead" at all points except alongside the trains using it. Contradictory as this appears, it has been thoroughly demonstrated, and, of course, eliminates the deadly characteristics of the third rail with its heavy charge of electric current. It is also claimed that this deadening



Barmen Suspended Railway, showing Turn.

of the feeding rail saves thirty per cent. of the power required to operate a system, and that there are various other economies. If this invention can be reduced to commercial practice, it should supersede the overhead trolley and the present "third-rail" systems.

In 1902 experiments were made for the New York Central road with electric and steam trains of various lengths, to demonstrate their relative efficiency for short-distance work, as for handling the traffic in the New York City tunnels. The locomotive used was one specially designed for handling suburban traffic, the best that could be bought. Two motor cars were used in the electric train, of a total weight of 72½ tons, and of nearly the same capacity as the locomotive. The drawbar pull or starting effort of the two trains was the same, but the results figured up in every instance in favor of the electric train, as shown in the following table:

MILES PER HOUR ATTAINED IN TEN SECONDS.

Number of trailers	1	2	3	4	5	6
Electric train	22.5	20.7	17.3	14.4	12.6	11.2
Steam train	14	13	12.5	12	10	9.7

MILES PER HOUR ATTAINED IN TWENTY SECONDS.

Number of trailers	1	2	3	4	5	6
Electric train	34	32.3	29.4	27.4	24.5	21.2
Steam train	25	21.2	21.5	19.5	18	16.3

MILES PER HOUR ATTAINED IN THIRTY SECONDS.

Number of trailers	1	2	3	4	5	6
Electric train	38.2	36.4	34.2	32.4	30.3	28.1
Steam train	31.7	26.2	27.2	24.7	23.2	20.8

It will be noted that the locomotive came nearest the electric train when pulling the longest train of six cars for the shortest time —ten seconds; yet even here it was far enough behind to warrant its displacement in favor of the electric train. A curious fact was that the electric trains consumed less power in making the same distance than the steam trains, and that when the power was shut off at three-quarters of a mile from the starting-point, as it was in all the tests, the electric train was brought to a stop in half the distance required to stop the steam train. This was accounted for by the fact that the electric trains did not attain as great speeds as the steam trains at the point where the power was shut off. The electric trains made greater speeds for the total distance because they started so much quicker. Several years ago it was determined, by those handling the trains at the New York end of the Brooklyn bridge, that the trains could be shifted to another track and reversed much more quickly by electric power than by steam, and electricity has been in use there ever since.

One of the most remarkable railways in the world is the Langen suspended railway at Barmen, Germany. It is elevated in more senses than one, as the rails are above the cars. A structure of girders rises nearly forty feet above the ground level, being supported by great A-shaped frames at intervals, or sometimes frames of inverted U shape. The rails are set in this structure some

Courtesy Scientific American.

Barmen Suspended Railway.

twenty-five or thirty feet from the ground, and the cars are hung below them, suspended in mid-air. They go skimming along by electric power, making the nine-mile run from Vohwinkel to Barmen in half an hour, notwithstanding there are eighteen stops.

The arrangement of the supports and girders will be more readily understood from the illustrations than from any written

description. The motive power is electricity, applied direct to the two wheels, which are thirty inches in diameter, and set twenty-five feet apart, so as to run tandem on a steel rail. The wheels have flanges on both sides, to prevent their running off the track, but even if they did jump the rail, the car cannot fall, because its upper structure is so hooked around the girders that they cannot be separated unless the whole structure tumbles down. Swinging or rocking of the cars, as the passengers get on or off at stations, is prevented by a spring rest that bears against the edge of the station platform.

An automatic block system of operating the trains is employed, this being worked by the passage of the cars, and permitting them to run under only two minutes' headway. The cost of constructing the road was about $215,000 per mile, or rather more than the ordinary form of elevated road, and very much more than the surface road. What induced the engineers to plan such a railway is a puzzle; it may be that the ground over which it travelled was of such uneven character that this system was as cheap as any that could have been devised; anyway, there must have been some reasons not apparent superficially.

Mountain railways are wholly *sui generis*. Sylvester Marsh, an American, taught the world how to build them, constructing the first up Mount Washington, which was completed in 1869, at an expense of $150,000. The mountain is the highest in America east of the Rockies, its summit being a mile plus more than a thousand feet above the sea-level. To reach this elevation, Marsh had to find means to drive a locomotive up a grade of one foot rise in an advance of 2.67 feet. This he accomplished with the cog-rail, which enabled the locomotive to take a firm grip by means of toothed wheels. By reducing the speed greater power was obtained, and Marsh made the ascent without serious difficulty. Swiss and German engineers came over to see Mount Washington railway, and it was soon imitated at Mount Riga and elsewhere in Europe.

The Pike's Peak railway, completed in 1890, is longer, but has not such severe grades as the foregoing, one foot in four being the steepest; its length is nearly eight miles. The summit is over 14,000 feet above the sea-level, and bears the highest observatory of the Weather Bureau. The cog-rails used on this line are very heavy pieces of steel, less than seven feet in length. The locomotives used on this and other American mountain lines, as now made, have boilers set about eighteen inches higher at the rear than the front, so as to render them level on an average grade. The driving

shafts and gear are made in duplicate to avoid danger from accident. The crank-shaft turns around four times to one revolution of the driving axle. The driving axle bears a very heavy cog-wheel, two feet in diameter, that meshes with the cog-rail.

If the European builders of mountain railways came after ours, they have made up by building more of them and over steeper routes. The steepest in the world is the Pilatus, in the Alps, which has a grade in one section that ascends forty-eight feet for every one

On the Pike's Peak Railway.

hundred of advance. A steel wire cable is used on this road, as also on another very steep road, near Lucerne, Switzerland. The latter uses electric driving power, and dispenses with the cog-rail, being therefore almost as much like an elevator as a railroad.

An idea of the locomotive business of the United States may be gathered from the census figures of 1900. During that year 3046 locomotives were built in fifty-four shops, nearly one-half of them coming from Pennsylvania. A little over one-sixth of these were exported. Their average cost was almost exactly $10,000 each, which was an increase over previous years, owing to the fact that

the average locomotive grows larger every year, so to speak. In 1890 the average weight of those built was about 92,000 pounds; in 1900 it was 129,000, and in 1904 it is estimated as 138,000. The construction of locomotives has been steadily improved, by compounding the cylinders, increasing the heating surface, etc., and cost kept down by constructing the driving-wheel centres, main frames, and sundry other parts of cast steel instead of wrought iron, as formerly. About 150 electric locomotives were built in 1900

A Compressed-Air Mine Locomotive.

for use in mines, also a number of compressed-air locomotives for the same purpose. One of the latter is here illustrated. It has a sort of beheaded appearance, having no smoke-stack. The storage tank is filled with air, which may be compressed to a pressure as great as 1000 pounds to the square inch, or in a few extreme cases more than double that pressure. It is not used at this pressure, however, being valved to a low-pressure reservoir from which the air can be supplied to the driving-cylinders at a uniform working-pressure.

In 1876 the average freight car on United States railways had a capacity of forty tons; in 1885, sixty tons was reported as the average; in 1895 the cars built averaged about seventy tons; in 1899 the figure had grown to eighty tons; while to-day pressed-steel cars of one hundred tons capacity are being turned out at an enormous rate. Although the pressed-steel car industry only started in 1897, so quick are the railways to adopt something in the line of economy that in 1901 it was reported that more steel was required for making cars than for any other purpose. The Pittsburg Pressed Steel Car Company's standard coal car is shown in the illustration.

Why steel cars were not thought of sooner is a mystery. The steel has a theoretical advantage over wood at the start, as the amount of metal required as compared with wood is about ten or twelve per cent. less in weight for the same strength. Farther, it is thought to be three times as durable, reducing the cost of repairs about seventy-five per cent. Some steel cars built as an experiment

for the Western Railway of France in 1869 were reported as still in good condition in 1897. When the railroads began to use them, other advantages speedily developed. The "dead load," of cars that has to be hauled, is reduced from one-third of the weight of the train to one-fourth, and this saving counts not only in hauling a load, but in hauling back "empties." A train of the same capa-

A Pittsburg Pressed-Steel Car.

city is shorter, requires less switching, and will go on a shorter siding. A report made on the American pressed-steel cars at the International Railroad Congress in Paris, in 1900, showed that while the net earnings of an average wooden car were $69 a year the steel car earned $163.50.

In building steel cars, what is known as medium-soft Carnegie steel is employed, of a strength of 60,000 pounds to the square inch. The stock comes from the rolling-mill in the form of large plates, and is first sheared to size, and then pressed. The larger pieces that require but slight forming are pressed cold by great hydraulic machines; the smaller pieces that are more or less complicated in form are heated to a cherry-red and then light-pressed. The work is continued in the drilling and riveting department, where special machines make the holes and fit the parts with very little hand labor. They are put together in the erecting department, where some hand riveting is essential. Pressed-steel bolsters for the trucks are now commonly supplied, so that the cars are literally of steel all through.

The cost of building railway lines has been greatly reduced within a few years. The improvements in excavating machinery and in methods of filling in have been marked. Dynamite is used to break up the rocks, and giant steam-shovels pick up the broken stone, gravel, and sand and dump it all on flat-cars, to be unloaded at some other point for building up the roadway. The latest unloading machine, which is a marvel of economy, is described in another chapter.

When it comes to track-laying there is now a machine for doing all the heavy work, saving handling, and capable of laying in place the ties and rails for two miles of track in a single day! This mechanism was devised by R. E. Hurley, of Scranton, Pa. The construction train consists normally of sixteen cars loaded with rails, ties, etc., hauled by a machine car that is part locomotive. This machine car has a trussed derrick with a sixty-foot extension that projects out over the track as desired. A car containing a boiler, fuel, and water is also included in the train.

The Hurley Lightning Track-Layer.

The sixteen cars are provided with rollers on which the rails rest. Men on the cars loosely bolt the rails together in parallel lines, and these strings of rails are pulled forward by the machine car. The proper number of ties are laid on top of the rails as they roll along to the machine car. Arriving there a mechanism picks off the ties and carries them ahead, dumping them a little more than a rail-length in advance of the working point, so that laborers have time to adjust them before the rails come along. As the rails arrive at the front, they are unbolted from the line and swung into place, men on the ground guiding them to position. When a rail is in place a man bolts it quickly, and the train runs forward as soon as a pair of rails are laid in advance, when the next pair are laid in the same manner. The machinery is so geared as to move forward the line of rails and ties the same distance that the train advances, so that the proper material comes to the right place with every advance. Only forty men are required with this outfit to lay track at the rate of more than a thousand feet an hour.

Almost as ingenious as this method of track-laying is the Lidgerwood system of shifting a railway track. The old method was to employ a gang of laborers with crowbars, who unbolted the rails at intervals, and worked them to one side at great expenditure of physical strength. The new method, which is practised for temporary tracks used in construction or cutting away of sand-banks, etc., consists in simply hauling a long section of track bodily by means of a steel cable and locomotive. The line of rails and ties being first loosened from its moorings, a flat-car bearing a winding drum for wire cable is firmly anchored to one side. One end of the cable is attached to the track, a few turns are taken around the

Throwing a Railway Track.

drum, and the locomotive, which has been made fast to the other end, is started up gently. If everything has been properly adjusted, the track comes over where it is wanted,—that is, a part of it does,—and the locomotive and flat-car are moved along to attack another portion, and so on until the whole track is moved to where it is wanted. The *Railway Review* says of this system:

"To throw a mile of track laterally and to a lower grade by hand labor requires the services of a large gang of men for a whole day, and the average expense on this road has been about $175 per mile. By using the unloader the track can be shifted to place at a cost of about $43 per mile, the ordinary distance being 15 feet laterally and an average of 10 feet vertically. The time required to do the work in this manner averages 7½ hours. The expense stated covers the use of the unloader, locomotive, and crew, four laborers and one foreman.

"When one side of the cut has been excavated, the old track is thrown down to the lower level to be used for a loading-track in excavating the other side of the cut and a new track is usually built to carry the traffic."

The use of signals for running trains more safely has increased very much in the last dozen years of American railroad history. As traffic increased and trains were required to run closer, the necessity for more signals and greater accuracy grew correspondingly. Block signals are now commonly used in this country to space fast trains, while interlocking signals have been introduced at all large railway yards, terminals, drawbridges, etc. The impression seems to prevail with the public that the block system of operating trains is used on every bit of railway in the country, and it may be a shock

Courtesy Scientific American.

Block Signal System, Pennsylvania Railroad.

to some to learn that only one-eighth of our railway mileage is protected by this system. In Europe the use of signals is not as fully established as it is here, but in all parts of the world the tendency to use them is increasing rapidly.

To understand the automatic block signal system, let us first suppose that a mile of track represents a block. As soon as a train enters this block, its wheels and axles form an electrical connection between the two rails on the ground, which are charged with a current for operating signals. The train making this connection de-energizes an electromagnet and allows a semaphore arm to assume a stop-position, which notifies any following train that there is a

train in that block. The semaphore arm remains at stop-position just as long as there is a train in the block, and the instant it passes out of the block the electromagnet is energized and pulls the arm to the "all-clear" position. Where the traffic is heavy, the system is often duplicated, and at each signal-post set at the entrance of a block the engineer is informed of the condition of the track for two blocks ahead, and knows that it is safe for him to put on speed, or that he must reduce speed and be prepared to stop a mile farther on, if the second block is not cleared when he reaches it. The only accidents that can happen to the signalling apparatus result simply in giving the signal to stop. In other words, the mechanism cannot give the "all-clear" signal unless the track is surely clear. If any one should try to tamper with it, or the magnets should give out, the result would be a signal to the engineer to stop.

Where there are a number of railway switches at one point, constituting an important junction, railway yard, or the like, an elevated signal cabin is employed, in which an operator stands and throws levers to operate the switches. By a system of interlocking, he is prevented from ever throwing conflicting switches; that is, if he throws a switch to send a train from track one to track five, and it has to pass three other switches to get there, these other switches are kept closed by the same movement of levers that opens the switch for track five. The signalman can make mistakes, as human nature is prone to do, but the interlocking system prevents his making dangerous mistakes. He can send a train to track four when he should send it to track five, but he cannot send two trains on to track four at the same time, nor can he cause collisions by inadvertence. In interlocking systems the switches are most commonly pulled by rods and levers, and when there are many of them in a railway yard, they are boxed over for protection; but where the number of switches is so great that these become cumbersome to handle, and use up ground space that is wanted for other purposes, compressed air and electricity are used to operate them.

At the Grand Central yards in New York City, the switches and signals are all worked by a low-pressure pneumatic system. In this case the operator, in pulling his levers, simply sets certain valves, which admit air, under a pressure of fifteen pounds, to certain pipes and do the work of setting the switch.

A vast number of inventions have been patented for the purpose of reducing the dangers of railway travel. When we reflect that the railways of the United States alone kill over eight thousand five hundred persons a year through accidents, it is not sur-

prising that safety devices are numerous. The wonder is that the railways do not employ them. Of course, it may be argued, in favor of the railway companies, that a great majority of these inventions are impractical. This is true, but many that are quite practical are not adopted, and the block system, which is the best in practice, is yet to be applied to about 175,000 miles of our railways!

The official figures of railway accidents constitute the most appalling record. *Every twenty-four miles of railway track in the United States sees one person killed every year, and every three miles sees one person injured.* Following are the official figures, which are worthy of study, and should arouse the public to some action tending to reduce the dangers:

RAILROAD ACCIDENTS IN THE UNITED STATES.

(From the Report of the Interstate Commerce Commission.)

Year Ending June 30.	Employees.		Passengers.		Others.		Total.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
1898	1958	31,761	221	2945	4680	6176	6859	40,882
1899	2210	34 923	239	3442	4674	6255	7123	44,620
1900	2550	36,643	249	4128	5066	6549	7865	50,320
1901	2675	41,142	282	4988	5498	7209	8455	53,339
1902	2969	50,524	345	6683	5284	7455	8588	64,662

The total number of passengers carried in 1902 was 649,878,505 as against 607,278,121 in 1901.

Kind of Accident.	Employees.		Passengers.		Others.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Coupling or uncoupling	167	2,864	.....	.....	.....	.....
Collisions	424	2,759	133	2360	60	231
Derailments	209	1,301	37	1069	47	134
Parting of trains	23	418	.....	82	5	32
Locomotives or cars breaking down	21	192	.....	8	4	12
Falling from trains, locomotives, or cars	491	4,667	53	372	358	636
Jumping on or off trains, locomotives, or cars	140	3,336	67	984	430	1445
Struck by trains, locomotives, or cars	926	1,699	39	410	3982	3563
Overhead obstructions	83	729	.....	.....	.....	.....
Other causes	298	9 350	15	1153	348	1144
Total	2782	27,315	344	6438	5234	7197

Two hundred and twenty-eight persons were killed and 23,712 injured in handling traffic, tools, machinery, supplies, etc., and in getting on or off locomotives or cars at rest and from other causes.

According to the *Railway Age*, during 1902 1096 persons were killed and 6661 injured on English railways. The proportion of passengers, exclusive of season-ticket holders, killed or injured in train accidents from causes beyond their own control, was one in 198,036,545, and one in 1,623,250, respectively; and the proportion in all classes of accidents one in 9,211,002 and one in 466,700. Of the 447 railway employees killed, 92 met their death in switching accidents, while of the 3713 injured, 2013 received their injuries from the same cause. The list of killed includes 135 suicides.

THE LIGHT OF TO-DAY AND OF TO-MORROW

As the heavens are dotted with blazing stars, each a sun sending its glow through measureless miles of space, so is the earth being decked with artificial lights by the efforts of mankind, and light-giving inventions are heralded with almost as much *éclat* as though they paralleled the illuminations of nature. Although we value artificial light so highly, yet it is one of the things that we could do without were we so minded, for there are hours enough of daylight, and no place above ground is obscured from the sunlight except by man's own structures. But the restless activity that has made man master of the earth seems to bid him work on after the sun has set, or play on if he has stopped his work, creating a strong desire for artificial light, which is looked upon as a necessity.

From the rush-lights of our ancestors to the great search-lights of the twentieth century is a long journey, and we can spare very little space to trace the connection. First, the rush-light, then the candle, next the kerosene lamp, improved by the Argand burner; then coal-gas, with a side development later in the Welsbach mantle; and not forgetting the lime-light, once the synonym for excessive brilliancy; until we reach the light comparable with sunlight, before which all our other lights pale,—the electric arc, made of real lightning, but harnessed for use and not destruction.

The electric light is nearest the sunlight in character and power. In fact, we do not know how much the sun's light may be attributable to electricity, rather than simple heat, for the theories of electricity and ethereal waves are much metamorphosed by late discoveries, and the more eminent the student of science the more ready he is to tell you that he does not know just what sunlight is, or how the sun gives off such great heat and light.

Electric lights are of two general classes, incandescent and arc. The current used to produce an incandescent light is what is known as a low-tension circuit, of commonly 110 to 240 volts, and the shock that is received by a person through whom it happens to pass is not severe enough to do any harm. The arc light is produced with a high-tension current that varies from 2000 to 5000 volts, either of which is fatal to one receiving the full force of the voltage.

The incandescent light is produced by a continuous current, and the arc light by an alternating current. The continuous cur-

rent is brought from a dynamo having the commutator and brushes so arranged that they take up all the impulses of the same polarity, conducting them away by one brush while the impulses of the opposite polarity are conducted away by another brush. As a result, the current of one brush is always positive and the other negative, and the current is not interrupted, but flows continuously in one direction. In the alternating current dynamo there is one polarity when a section of armature coil is approaching a north field magnet pole (or receding from a south pole), while the other polarity prevails when receding from a north pole. In this way there are produced with great rapidity impulses of opposite polarity.

There are some 3000 electric-light stations in the United States, Illinois having the largest number, closely followed by the States of Pennsylvania and New York. The total capitalization of these plants is about $700,000,000, and the actual investment is believed to be about one-half that sum.

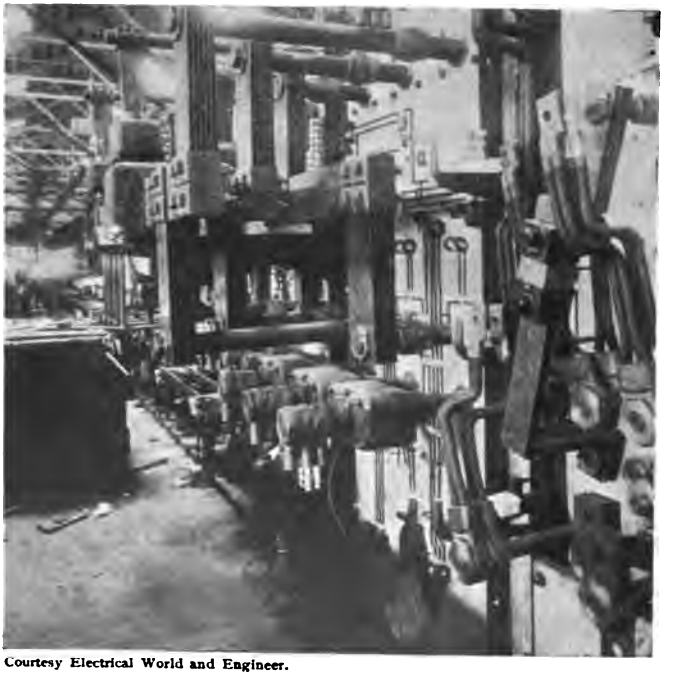
In arranging an electric-light plant, one of the first considerations is that all machinery shall be duplicated, so that in the case of accidents (which will happen) one set of machinery can be thrown out of use and another set thrown in. A common method in large plants is to provide two distinct engine rooms, two fire rooms, and a switchboard room, communicating with each other but capable of instant and complete electrical separation, so that in case of trouble of any sort the man at the operating table that controls the switches can manipulate the connections so that the load of work is transferred to portions of the stations not affected by the difficulty.

The switchboard of a large electric-light plant is a board in name only, being rather a place where the switches are located. They may be mounted on rows of iron posts, one row of posts for positive and another row for negative switches. The best practice is to operate the switches by motors, providing interlocking mechanism to prevent short circuits. Of course, they are also operable by hand. At the operating table a man controls the whole situation, and can change any of the connections through the switches, as well as control the field regulating rheostats. This not only reduces labor, but renders results more certain. What the patrons of an electric-light company demand is a constant service, and by such means the little difficulties that will occur with all classes of machinery are prevented from annoying the customers.

Since an electric-light plant is simply a mechanism for converting steam power into electric currents that may be used for

Courtesy Electrical World and Engineer.

Front of Switchboard.



Courtesy Electrical World and Engineer.

Rear of Switchboard.

lighting, it is evident that a most important part of the outfit consists of boilers, engines, and piping. The boilers usually stand in rows, and are fed with mechanical stokers, the coal being brought in by conveyors, and the ashes carried out in the same way, so that hand labor is reduced to a minimum. The latest boilers are equipped with superheaters and all up-to-date contrivances for providing the most steam at the least cost. Even the charge for water is seriously considered, and reduced in some cases by means of condensers for using it over again. This would be the common practice were it not that a limit is set to the re-use of water, because it gathers oil from the cylinders and tubes, and this is liable to prove dangerous.

The steam piping for an electric-light plant is very elaborate and involves much expense. The pipes that carry the steam from the boilers to the engines require to be so valved that any boiler can be used to supply any desired engine, and this must be accomplished with as little loss of heat as possible. The engines are usually direct-connected to the dynamos, which latter thus send out the strong currents which the man at the operating table may direct to any line within his field.

The incandescent light derives its name from the red-hot carbon filament enclosed in the glass bulb, which is deprived almost wholly of air. This light is based on the fact that electricity heats a poor conductor. The thread-like filament in the bulb is of carbonized cellulose, and when, by turning a knob, we admit a current to the filament, its poor conducting qualities make the passage of the electric current so difficult that it heats, becoming red hot almost instantly. If it were not for the partial vacuum in the glass bulb, the filament would burn up in another instant, but oxygen is essential to combustion, and by pumping out all the air possible from the bulb, the oxygen left is of such small quantity that the filament cannot burn readily, but lasts for months, usually until some leakage admits the air, and the filament as a result succumbs to combustion.

The arc light is made on a different principle. A very much stronger electric current is used, and directed through the two opposed finger-like carbons of an arc lamp. If the carbons touched each other, the current would pass through both without making any light, but they are placed a short distance apart, and the lamp is provided with a mechanism for keeping them at that distance. The current jumps this slight space, passing in the form of an arc or curve from the point of one carbon to the other. In thus passing through the air, it becomes a veritable streak of lightning,

so that the expression "harnessing the lightning" is not wholly figurative.

In the older styles of arc lamps the air had free access to the carbon points, but it has been found better to enclose them, and the latest lamps are so made. The trouble with the exposed carbons was that they burned away so rapidly, and the lamps were in use a number of years before the makers devised satisfactory feeds for the carbons, so as to keep them at an even distance apart and prevent flickering of the light. After the current was turned through the carbons for a few minutes, they became pointed, and the upper carbon, which is the positive, from which the current flows down, burned away about twice as fast as the lower. A little hollow formed in the point of the upper carbon, and the greater part of the light coming from this hollow was thrown downward at an angle of forty-five degrees, whereas it should go out sideways to spread the most light.

The new enclosed light has a globe that, while far from air-tight, serves to keep away the air sufficiently to reduce greatly the burning of the carbons. The ends of the carbons do not become pointed, nor does the positive carbon tend to form a cup or hollow. It is also possible to keep the carbons at a greater distance, thus lengthening the arc and increasing the power of the light.

The flame-arc lamp is a still later improvement. With this the carbons are soaked in salts of barium or lime, which produce vapors that tend to a considerable increase of luminosity, and permit still greater lengthening of the arc. Zeidler's intensive flame-arc lamp is constructed with the carbons side by side, but forming an acute angle like the sides of a capital V. Both carbons as they burn away are advanced by the mechanism, and as they point downward there is no shadow below. When this lamp is enclosed in a globe and placed in the focus of a suitable concave reflector, it is five to ten times as effective as the ordinary arc lamp, of the same current power, as made a few years ago.

The use of salts to intensify light grows out of the lime-light, as discovered by Drummond, of England, in 1826. He found that, when a piece of quicklime was exposed in a hot flame, as that produced by an oxyhydrogen blowpipe, the glare of the flame was greatly increased. On this discovery was based the lime-light, and it was the study of this principle that enabled Welsbach to produce his gas mantle for doubling the efficiency of a gas flame.

Welsbach hunted for a better material than quicklime, and found it in the salts of certain rare earths, as thorium, neodymium,

etc. By searching he found that these earths were not so rare as supposed, and, having cornered a supply in North Carolina, the Welsbach Company was formed to exploit the mantle. This is a simple sheath as large or a little larger than a man's thumb. It is formed of loosely woven cotton, soaked in the salts, which dry over the cotton. When this mantle is hung over a gas flame, the cotton burns away, and the very fragile coating of salts remains to give out its soft and pleasing luminosity until by some accident it is crushed. An important improvement made by Rawson in 1889 provides for coating the mantles with paraffine or the like to toughen them, rendering transportation much safer. This mantle is also applied to gasolene lights with remarkable results.

Auer von Welsbach, the talented inventor of the mantle, has devised a new filament for incandescent electric lights. He substitutes osmium for the carbon filament, and, as this has natural luminosity, it should greatly increase the power of incandescent lamps with a given current. However, the efforts of Edison and the other inventors in the incandescent-light field were to secure an electric light of low power, as the demand for house-lights does not call for any greater brilliancy than that commonly employed. So there may not be much field for this.

Another invention of much promise that is just coming on the market is the Nernst electric lamp, which was first developed by the General Electric Company of Berlin, and is now manufactured in Pittsburg. It is based on the fact that a filament of a non-conductor, such as magnesia, becomes a good conductor after it is heated. It is made somewhat in the form of an electric incandescent lamp, but has an open bulb. The filament is made thick and short, and it requires to be lit with a match or other flame, to start the heat, after which the electric current, which may be either continuous or alternating, produces the light. The light produced is whiter and more brilliant than the electric incandescent, as far as appearances go, and the claim is made that it has twice the efficiency. The lamp certainly has the merit of having less perishable parts than the electric incandescent, as the filaments can be more easily and cheaply replaced.

The search-lights commonly used by vessels of war are electric lights supplied with large reflectors to send the beam all in one direction. Some of these are very large, the one shown in the illustration being located on Mount Lowe, near Pasadena, California, having 3,000,000 candle power, and owing to its elevation being visible at times at a distance of about 100 miles.

Acetylene gas has made considerable progress as an illuminant. It gives out about ten times as much light for the same volume of gas as does a good grade of water-gas, but its odor is unpleasant, and it suffered at the time of its introduction from efforts made to impress the public with the notion that it was dangerous for general

The Nernst Electric Lamp.

use. Having been proven to be no more dangerous than other gases, or than electric currents, its progress in public favor has been steady. Some seventy-five towns and municipalities in the United States employ it for public lighting, besides about fifty in Germany and thirty in France. It is also used by fifty or sixty railroad companies in America, including such lines as the Great Northern and Southern Pacific.

Acetylene gas is a combination of two parts hydrogen and two parts carbon. It was first known in 1836, but was very expensive to produce until the introduction of the electric furnace enabled calcium carbide to be manufactured cheaply. It is now commonly produced by allowing water to drop into the calcium carbide, and when decomposition sets in the gas rises and may be carried off and burned like ordinary coal-gas.

The first patent of any consequence for the production of acetylene gas for illuminating purposes was granted to Thomas

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Projector on Mt. Lowe, California.

L. Willson in 1895. His success stimulated invention to such a degree that some 600 patents have since been issued in the United States for acetylene apparatus. A great variety of means are employed for bringing together the water and calcium carbide; in some the water falls drop by drop upon the carbide, a regulating valve determining the amount of water, and hence the amount of gas manufactured; in another and opposite arrangement, a regu-

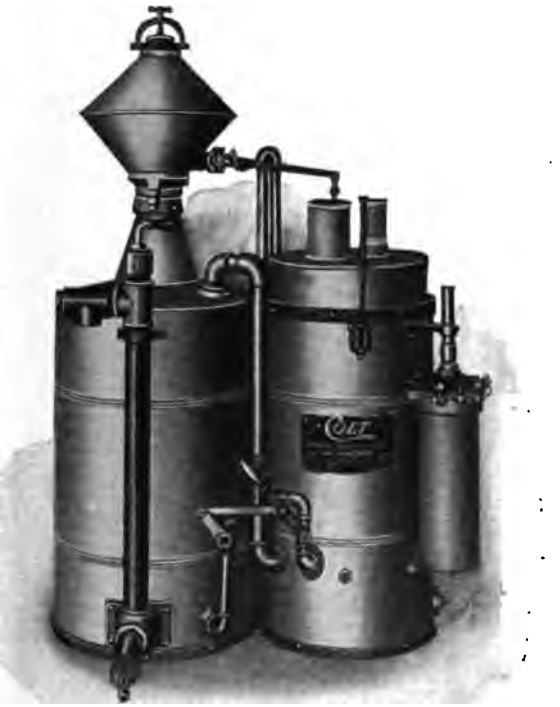
lated quantity of powdered carbide is dropped into water. The Criterion generator is a simple form of acetylene-gas apparatus operated on the first-named principle. In this a series of metal jars are suspended in a circle from a post; the jars are filled with carbide, and water connections are made in such a way that a regulated

Carter Acetylene Generator.

quantity of water flows into each jar, one after the other, while the gas generated is carried into a rising and falling holder.

In the Carter acetylene generator the carbide is contained in the generator, or large outer box, in trays, each compartment containing about one pound of carbide. The flow of water from

the water tank is regulated by the rise and fall of the holder when at its lowest point, the water flowing into the first cell, extracting the gas from the carbide, and flooding it with water before attacking the next cell, and so on until the generator is exhausted. It will be understood from this principle that only one pound of carbide is at work at one time. The balance of the carbide in the generator, being in a dry state, can make no gas. This principle of operation enables the makers to guarantee that overproduction of gas and consequent loss will not take place in their apparatus.



Colt Acetylene Gas Machine.

The manufacture of calcium carbide is carried on at Niagara Falls, at Spray, North Carolina, and Sault Ste. Marie, Michigan, and the cost has been greatly reduced, being now in the vicinity of three and a half cents a pound.

Acetylene gas, burned through a half-foot burner, gives out the same amount of light as ordinary city gas burned through a five-foot burner, so that 100 feet of the former go as far as 1000 of the latter. In 1903 this 100 feet cost about 83 cents as against

$1, the common price of city gas. The making of acetylene gas is such a simple matter that every householder can have it, and hence it is to this illuminant the public look to reduce the price of ordinary water-gas, which is sold at an enormous profit in most large cities.

About two million acetylene lamps have been sold for use with the bicycle, and a larger form of lamp is popular for use on automobiles and other vehicles. They are also in demand on boats and launches, and a considerable number of search-lights are operated with acetylene.

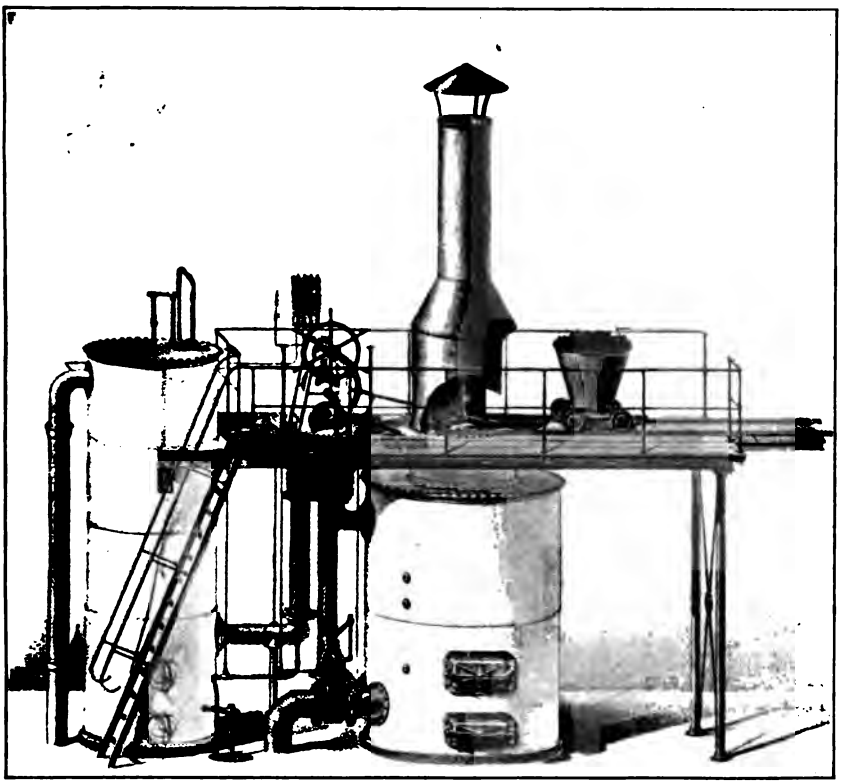
Coal-gas for house lighting was introduced in the United States about 1821, and has become one of our most important industries. Notwithstanding the progress of the electric light, and the fact that petroleum lights are still in great demand, the manufacture of gas for lighting purposes continues to be a prosperous business throughout the entire civilized world. The quality of a gas for illuminating depends largely on the quality of the coal used in making it, although there are artificial means for increasing its illuminating power. The quicker coal is turned into gas after mining, the more gas it will make, as it loses by being stored in the open air.

The first process in gas-making is distillation, which consists in heating the coal in a large vessel or retort, which process will yield a little over 10,000 cubic feet of eighteen-candle power per ton of Pennsylvania gas coal. The retorts used are made of clay, or sometimes of cast iron; the round form of retort has strength and durability, but is inferior to the D-shaped or oval form as a carbonizer. The coal treated in the retort becomes coke, and by heating this until it glows, and then forcing steam through, about 30,000 feet more gas are obtained, this being the principle by which water-gas is made, the decomposition of the water passed through the coke releasing hydrogen and giving this increased output.

By far the greater portion of the gas now manufactured is water-gas, this process producing so much more gas from a given quantity of coal, though it has the disadvantage of being much more poisonous. It is also somewhat deficient in illuminating power, so that it has to be enriched by carburetting, which process enables a percentage of petroleum vapor to become mixed with it.

Among the more recent processes for producing water-gas that of Dellwik and Fleischer is regarded very favorably by the gas trade. In the first producers built for their process, there were side

chambers into which the fuel was fed, but these have been abandoned, and the producer is now built in the cylindrical form shown in the illustration, being usually ten or twelve feet high, and having the fuel supported on a grate, beneath which the air is blown. The coke fuel is supplied at the top by means of a small dump car, but, instead of filling the producer with the coke, only a thin layer is used. The tall cylinder at the left, it will be understood, is the scrubber.



Courtesy Engineering Magazine.

Dellwik-Fleischer Water-Gas Apparatus.

This new construction has produced valuable results. Owing to the small quantity of coke supplied at the fire-bars, the heating-up stage is reduced to about three minutes, while the gas-making blow is increased to eight or ten minutes, and the amount of water-gas secured from the coke is nearly double what it was under the old methods. A feature of the process is that there appears to be no loss at all of combustible gas, the products of combustion having no value whatever except for the heat, some of which can be saved for raising steam by the use of proper apparatus.

Mr. Dellwik calculates that 93.5 per cent. of the water-gas made by the above-described process is combustible, burning with a blue flame at a high temperature. The following table shows its composition:

Hydrogen	51	per cent.
Carbon monoxide	42	" "
Marsh gas	.5	" "
Carbon dioxide	4.0	" "
Nitrogen	2.5	" "

The average modern water-gas plant consists of a generator, carburetter, and superheater, for making the fixed gas, a condensing, scrubbing and purifying apparatus, and a gas-holder.

Sunlight Acetylene Gas Machine.

A gas-scrubber is a machine in which the gas is brought into contact with drops of water as they fall from one surface to another, resulting in the carrying of all the tar to the bottom of the scrubber. The machine also removes the ammonia and a portion of the carbonic acid and sulphuretted hydrogen from the gas. In operation it is first filled with water, after which the gas is turned

in, an effort being made to preserve the temperature at an average of 60° F. Each section of the machine contains a wheel having thin pieces of wood fixed horizontally across its spokes; all the wheels are turned by the main shaft, very little driving-power being required. Water is admitted into the machine at the rate of ten gallons for each ton of coal carbonized, and is drawn off from the lower part of the machine. The wheels rotate at a speed of four or five turns a minute, the cross-sticks on their lower halves being constantly immersed, while the upper portions present a large wet surface for absorbing the ammonia.

After scrubbing, the gas requires to be still further purified, the purifiers being large tanks, usually arranged in series; in these tanks the gas is treated with oxide of iron, or with hydrate of lime, or with quicklime, the former being the most used.

The gas-holder is the enormous tank by which the gas-works is usually recognized; it is different from other tanks in that its height is constantly changing according to the amount of gas inside. The larger portion of the tank rests on the gas itself, holding it down, and creating the pressure necessary to drive it through the mains to consumers. The holder is built within a guiding frame of trussed steel, in which it rises and falls as the gas is let in and drawn off. There seems to be no limit to the size of gas-holders, they having been constructed of a capacity of over 12,000,000 cubic feet, this being equivalent to about 400 feet diameter by 100 feet deep. The shells of gas-holders are made of sheet steel, riveted together, and set upon a concrete foundation.

Boston was the first city in the United States to adopt coal-gas for lighting, which it did in 1822. A gas company was formed in New York in the following year, and another in Brooklyn in 1825; Philadelphia and other large cities did not start gas-works until 1835 or later. By 1850 the industry was fairly well established, there being thirty companies, with $7,000,000 of capital, using materials of the value of half a million yearly and manufacturing gas valued at nearly $2,000,000. Gas companies multiplied rapidly in the next decade, there being nearly 300 in 1860. In the census year of 1900, 877 gas companies were reported in the United States, these supplying gas to 827 cities. Measured by the capital invested, gas is the fourth largest industry in the United States; measured by the number of establishments and the wages paid, it is the thirty-sixth, and by net value of products the thirty-third. The capital invested in 1900 was given as $567,000,000, which is remarkable as being more than double what it was ten

years previously, although the number of companies had shown only a slight increase and the amount of gas sold showed a gain of less than thirty-three per cent. in value. The increased capital is attributed largely to investments in new machinery and probably some-

Courtesy Scientific American.

Lighthouse Projectors.

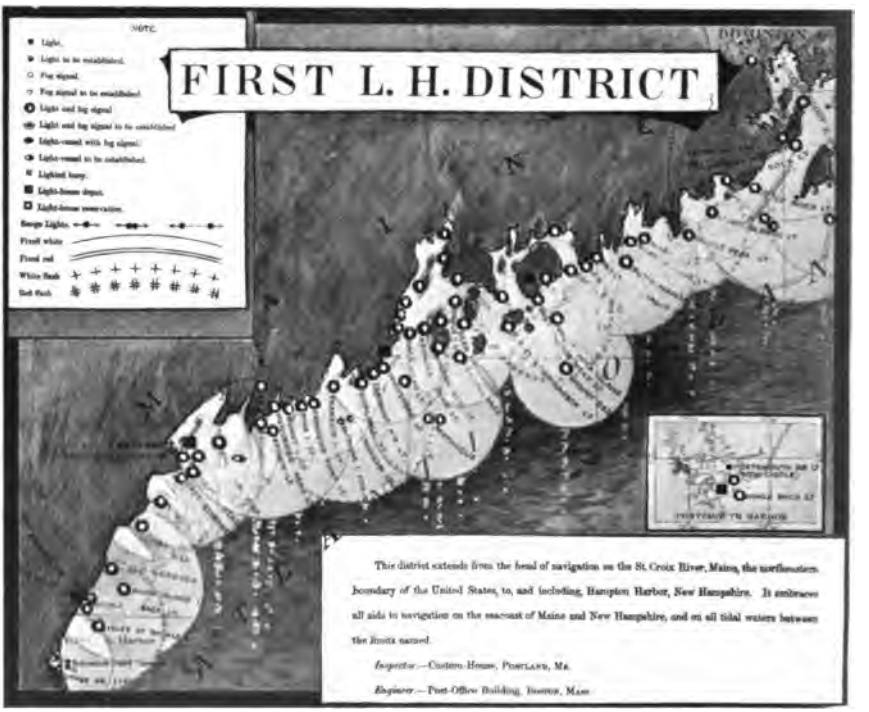
what to the modern tendency to overcapitalization. While the value of the gas sold in 1900 increased less than thirty-three per cent. over 1890, the quantity sold increased nearly eighty-four per cent., thus showing that there was a marked decrease in price. The average

price in 1900 was a minute fraction below $1 per 1000 cubic feet; in 1890 the average price was $1.42 per 1000. The lowest average in any State is Pennsylvania, where the cost is 83 cents per 1000, and the highest is Nevada where it is $4.50. The total quantity of gas sold, both for lighting and fuel, by the gas companies of the United States during 1900 was 68,000,000,000 feet. It is an astonishing fact that New York City alone consumed twenty-seven per cent. of the country's total output of gas, 18,000,000,000 feet being required to supply the wants of Greater New York in the closing year of the century. Why this large consumption does not permit a reduced price in New York is a mystery to Gothamites. If these figures were other than official, they would hardly be believed: yet this is only one of a number of indications of the extraordinary activity prevailing in the largest city of the New World.

Another curious fact gleaned from the census returns is that the gas companies spend more for oil than they do for coal. In the early history of the gas companies coal was the principal item of expense, but with the development of the water-gas process most of the gas is made out of water, and in order to give it illuminating quality, or in other words cause it to burn with a white flame instead of a blue flame, the vapor of petroleum is added to the gas as an enricher, and the demand for a good quality of gas has resulted in the use of more and more oil, until the condition was reached, in 1900, where the gas companies' yearly bill for oil was over $8,000,000, as against a little over $7,000,000 paid for coal. The competition of electric lighting, which has led to this improvement in illuminating gas, has resulted in giving the cities of the United States better gas than is to be found in European cities.

The lights supplied for lighthouses to protect mariners along the coast are, of course, the most powerful in ordinary use. The Light-House Board has charge of these in the United States, maintaining about 1400 stations. All important points on our coast line have lighthouses, with lamps that are visible from a distance of twenty-five or more miles; a very large number are visible at twenty miles and minor stations at fifteen miles or less. At no point on the coast where there is much navigation can a vessel reach the shore line without coming within the radius of one or more of these lighthouses. The lights in adjacent points are either differently colored or made to flash differently, in order that the mariner with a chart may know by these conditions what light it is that he sees. For instance, along the Massachusetts coast are the following: at Cape Ann is a fixed white light; at Boston

harbor, on a lightship, a fixed red light; at Race Point, a long and short flash white light; at Cape Cod, a white flash light; at Nauset Beach, a fixed white light; on lightship in Nantucket Sound, a fixed red light; on Nantucket Island, a long and short flash white light; at Gay Head, Martha's Vineyard, a lamp giving three white flashes and a red flash. The most important of the lights named is perhaps the Cape Cod light, which has a lens revolving in mercury, and gives a flash of 192,000 candle-power, visible at a


FIRST L. H. DISTRICT
This district extends from the head of navigation on the St. Croix River, Maine, the northeastern boundary of the United States, to, and including, Hampton Harbor, New Hampshire. It embraces all aids to navigation on the seacoast of Maine and New Hampshire, and on all tidal waters between the limits named.
Inspector.—Custom-House, Portland, Me.
Engineer.—Post-Office Building, Boston, Mass.

Map of Maine Coast, showing how it is guarded by Lighthouses.

distance of twenty-five miles. The rotation is so timed that the flash is seen every five seconds for a third of a second. The installation of this light in place of an inferior one cost $15,000. What is known as a first-order light costs the government about $90,000, including the structure. Nearly $4,000,000 a year is appropriated by Congress to maintain the lights, and to supply such new ones as the service demands, on the coasts, lakes and rivers of the United States. Some sixty light-vessels are under the control of the Light-House Board, the best of them being a steel steamer of 538 tons, whose annual bill for maintenance foots up $13,500.

The majority of the lights maintained by the Light-House Board employ oil as fuel, but the Pintsch gas-lights are in common use, and also a number of electric lights. Experiments have been made to test the value of acetylene gas as a substitute for the Pintsch gas, the engineers who made the test reporting favorably upon acetylene, as giving a higher candle-power for the same cost.

First-class lights in lighthouses owe their power very largely to the reflectors used. These are glass lenses, commonly called Fresnel lenses, consisting of ring-shaped prisms that send out the light in parallel rays. The light is centrally located in the foci of the lenses.

There are few lighthouses whose beams are visible more than twenty-five miles, indeed there is little reason for making them more powerful. On the island of Heligoland, in the North Sea, the German government has placed a light, with a special reflecting apparatus, said to develop 30,000,000 candle-power. This should be visible from a distance of about a hundred miles. But even this great light is thrown into the shade, so to speak, by the Lepaute electric-light beacon exhibited at the World's Fair in Chicago in 1892. Its great lenses, facing oppositely, are each nine feet in diameter. The powerful arc light focused therein is credited with developing 90,000,000 candle-power. This enormous beacon could be seen from a distance of a hundred and fifty miles, if sufficiently elevated to overcome the curvature of the earth's surface. The lenses and light together constitute a lantern, and are floated in a bath of mercury, to secure easy movement, as is customary with all large lights of the sort, and, although this enormous lantern weighs several tons, it can be turned around with the pressure of a finger.

During a thick fog lighthouses are useless, and this difficulty is overcome in a measure by supplying them with fog-signalling apparatus of one sort or another. The chief trouble with such signals has been the uncertainty of knowing the direction from which the sound comes. Strong steam sirens have been devised that could be heard for miles, but the most trained ears could not locate the direction with certainty, and this was a source of danger to the mariner. This difficulty has been met by the Hamilton-Foster signal apparatus, one of which is located at Faulkner Island. Experiments made by the Light-House Board demonstrated that a megaphone pointed directly towards a vessel drowned the sound from megaphones not directed towards it. The apparatus is provided with eight large megaphones, pointing towards the eight

principal points of the compass. A different sort of blast is sent through each of the eight, one long blast signifying to the hearer that the megaphone is north of him, one short blast, that it is south, and combination sounds for the others. Lighthouses provided with these are able to warn vessels of their nearness and position almost as certainly in a fog as in a clear night. A less expensive form of apparatus, for use on vessels, is made with one megaphone arranged to point at eight different directions in rotation, giving the proper signal in each direction.

Courtesy Scientific American.

Fog-Horn Plant on Faulkner Island.

The *World's Almanac* for 1904 contains the following statement as to a new selective or static converter, used in the electric-lighting industry. (See illustration, page 36.)

"Undoubtedly the most interesting single invention affecting the lighting industry was the public demonstration in London, early last year, before Lord Kelvin and other European savants, and later in New York, of the static converter of Peter Cooper Hewitt, which it was seen at once would play an important part in the future of the industry generally. Briefly, the system is intended for the conversion of alternating into direct current, the central feature of which consists in the utilization of peculiar properties of electrodes sealed in a receptacle containing vapor at a certain degree of alternation. Under this condition the electrodes act as electric valves, permitting passage to one portion of the alternating wave and suppressing another portion. A converter for 200 lamps, for example, is no larger than a 100 c. p. incandescent lamp, and is much more

simple in construction than the latter. The new converter of the size and capacity mentioned would weigh only a few pounds, whereas a rotary converter of the same capacity would weigh in the neighborhood of 700 pounds, and would be a complicated piece of mechanism. Although this converter was developed as a part of the Cooper Hewitt mercury-vapor lamp system, it has been found applicable to other forms of service. In the early experiments the invention did not handle above 3000 volts pressure, but it is announced that the range may be extended to 10,000 volts without the slightest apprehension."

Nikola Tesla has given out information from time to time of a new electric light upon which he was working, for which he has claimed excellent things, but which is not yet in condition for the market. He encloses rarefied gases in a tube, and sets up electric oscillations which cause a commotion among the molecules and atoms of the gas, causing them to move at speeds that produce light. The lamps arranged on this principle will last for years, requiring only to be supplied with electricity, usually by wires, but they can also be operated on the wireless principle. Commenting on his invention in the *New York Sun*, Mr. Tesla says:

"I have found that in almost all its actions the light produces the same effects as sunlight, and this makes me hopeful that its introduction into dwellings will have the effect of improving, in a measure now impossible to estimate, the hygienic conditions. Since sunlight is a very powerful curative agent, and since this light makes it possible to have sunlight, so to speak, of any desired intensity, day and night, in our homes, it stands to reason that the development of germs will be checked and many diseases, as consumption, for instance, successfuly combated by continually exposing the patients to the rays of these lamps. I have ascertained unmistakably that the light produces a soothing action on the nerves, which I attribute to the effect which it has upon the retina of the eye. It also improves vision, just exactly as the sunlight, and it ozonizes slightly the atmosphere. These effects can be regulated at will. For instance, in hospitals, where such a light is of paramount importance, lamps may be designed which will produce just that quantity of ozone which the physician may desire for the purification of the atmosphere, or, if necessary, the ozone production can be stopped altogether."

The future will probably continue to develop better lights than we have now, the tendency being to make business and travel by night as easy as it is by day. Our city streets are now five times as light at night as they were fifteen years ago, and the public do not consider a street half lighted if there is not enough light in it anywhere to see to read.

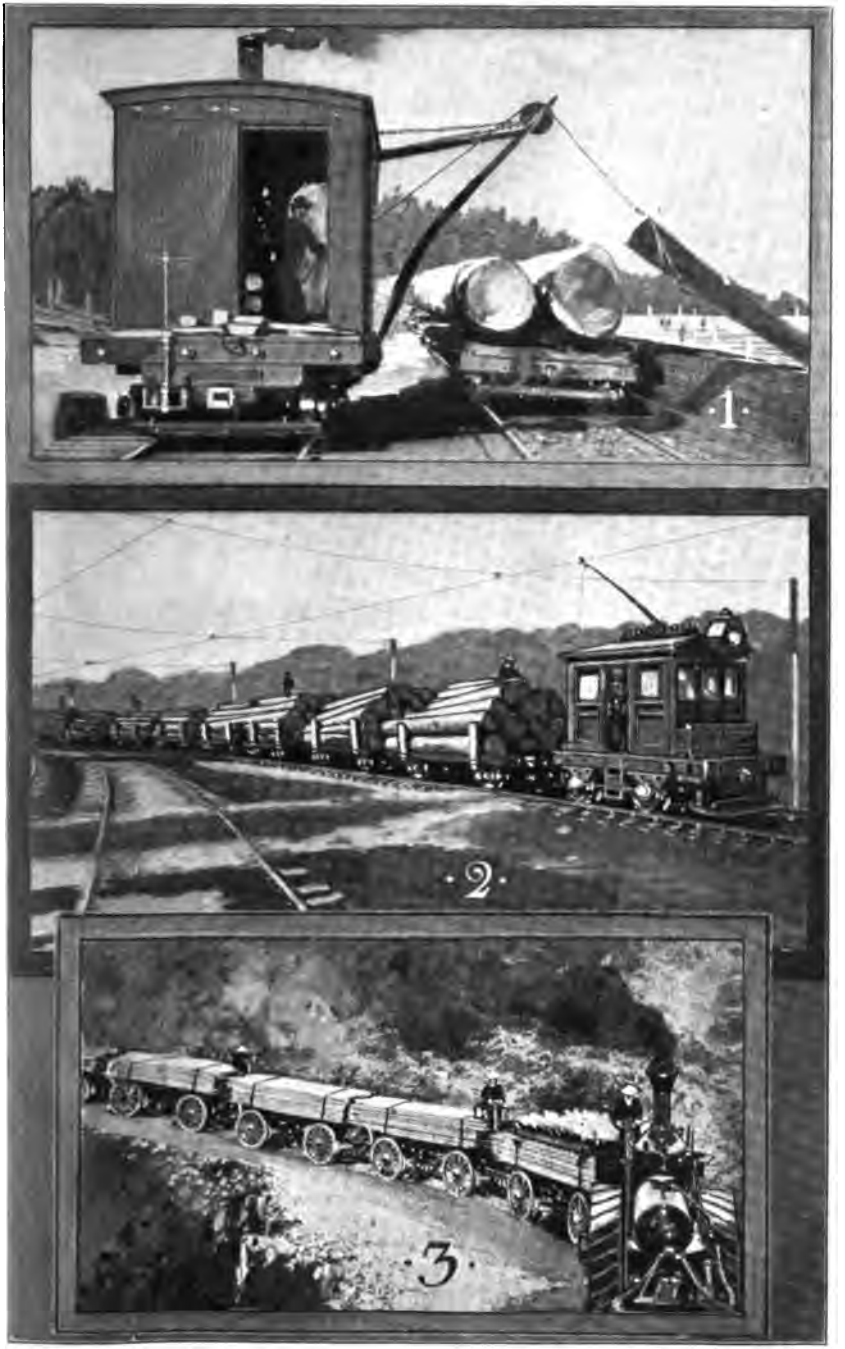
FROM LOGGING-CAMP TO PLANING-MILL

OUT in the woods, where the tall timber points heavenward, man sometimes seeks solitude, when tired of the turmoil and bustle, the greed and the gold-hunting, of much-habited lands. But in these days he must wander far if he would escape the sound of the woodman's axe, which is heard alike on the slopes of the Rockies, in the South African jungle and the Australian bush, along the great rivers of South America, and in the wooded preserves of Europe. Certain animals, as the beaver, and the most ignorant of barbaric races of men both use timber, and it was man's chief resource for manufactured articles until iron became so plentiful and cheap. Yet it has remained for civilized men to cut away the timber supply so ruthlessly that the attention of all nations has been drawn to the necessity of preserving the timber by wise legislation. In the United States alone an army of 200,000 men is occupied during the busy winter season in depleting the forests, while during the dull summer season about 100,000 are continuing the work of destruction.

In 1900 the lumber business ranked as the fourth largest among the great manufacturing industries of the United States. The capital invested amounted to over $600,000,000; there were 33,000 concerns or companies engaged in the industry, and nearly 300,000 wage earners. The amount of lumber produced by the mills during the census year was over 35,000,000,000 feet, board measure.

The lumber business is divided into logging-camps, saw-mills, and planing-mills. Of the total capital of lumber- and saw-mills nearly half is invested in the logging end of the business, but this investment is very largely in timber land, only nineteen per cent. of the total capital in the industries being invested in saw-mill plants, and only three per cent. in planing-mill plants. Thirty-five per cent. is live capital, that is money in accounts that is quickly changing hands. The mills of the North Central States are the largest and have the most money invested. The older settled States, as a rule, have a smaller investment in this industry than those of recent settlement, for the apparent reason that most of the lumber is already cut off in the older States.

Estimated in dollars, Michigan leads all the other States in logging-camps and saw-mills, though Wisconsin and Pennsylvania



The Lumber Industry.

1. Loading logs on steam railway. 2. Hauling logs by trolley.
3. Transporting lumber by road engine.

are close to her, and both of these exceed her in the value of planing-mills. Minnesota is also one of the leading States in the industry, Indiana, Washington, Arkansas, and Ohio following. New York State is conspicuous in the industry only because of its large number of planing-mills; not much lumber is cut there, but more lumber is dressed than in any other State of the Union. In round numbers, there are 15,000 logging-camps in the country, 32,000 saw-mills, and 10,000 planing-mills.

About one-twentieth of the wooded area of the United States is owned by the lumber companies, and this twentieth contains most

Primitive Lumbering in Kentucky.

of the best standing timber. There has been considerable scandal at one time or another as to the methods employed by lumbermen in securing control of land formerly owned by the Government, and doubtless the Government gave away under one pretext or another millions of acres of good timber land that should have been sold. For twenty-one years there was in existence a law by which any person cultivating ten acres of trees for a certain period could acquire title to 160 acres of land, and under this law about fifty million acres of timber land were taken up, very much of which subsequently passed into the hands of lumber corporations.

The older States were the first to recognize the necessity of doing something to preserve the forests. In 1885 New York established a forest preserve, which is now the Forest, Fish, and Game Commission, but this does little more than preserve the Adirondack region for the sportsmen. A few years since Pennsylvania provided for the purchase of 120,000 acres of land at the heads of the three principal river sources, in order to preserve the standing timber and maintain the water supply. The area was gradually increased, until the State's holdings for this purpose are now over 600,000 acres. Other States that have established official departments to care for

Timber Tract Destroyed by Fire.

the forests are Connecticut, Indiana, Kansas, Maine, Maryland, Michigan, Minnesota, New Hampshire, New Jersey, North Carolina, Oregon, West Virginia, and Wisconsin. A non-political organization of individuals interested has been formed under the title of The American Forestry Association, which has branches in most of the States and head-quarters in Washington, D. C.

In 1891 Congress authorized the President to constitute forest preserves, and Presidents Harrison, Cleveland, McKinley, and Roosevelt have each acted under the bill, until, in 1903, the total area of forest preserves totalled over 62,000,000 acres. Several States have passed laws designed to prevent forest fires, and Minne-

sota, New York, and a few other States have fire-wardens, whose business it is to see that the laws are enforced, or that those who infringe them are punished. Action of this sort is doing something to preserve what little forest land the State and national government control.

The chief species of timber cut for lumber in the United States are the white pine, common in New England and New York and along the great lakes to Minnesota; spruce, found mainly in New England and New York, although existing in the Rocky Mountain region; hemlock, occupying much the same range as white pine; cypress, found along the Gulf coasts and in marshy regions along the Atlantic; Southern yellow pine, growing principally in

Section of Lumber Flume in "Big Tree" District of California.
(Largest in the world, seventy-one miles long.)

the Gulf States; Western yellow pine, growing in the Rocky Mountains and on the Pacific coast; sugar pine, found mainly on the western slope of the Sierra Nevada Mountains; red fir, growing in Western Oregon and Washington; redwood, growing in a narrow strip close to the Pacific coast in California. To these may be added the hard woods—oak, poplar, maple, elm, and ash—growing principally in the interior States. Of these latter nearly two-thirds of the quantity cut is oak.

Pine furnishes the largest cut, and the white pine of the United States is giving out: however, the yellow pine standing is sufficient to last for another thirty years at the present rate of depletion. The saw-mills of the country cut up annually thirty-five billion feet of rough lumber, and over twelve billion feet go into shingles. The railway ties cut annually amount to 23,000,000 in number, of a value of over $6,000,000, while the million of telegraph poles produced are worth $1,400,000. The charcoal industry requires 7,000,000 bushels, and the tanners and others take half a million cords of hemlock bark.

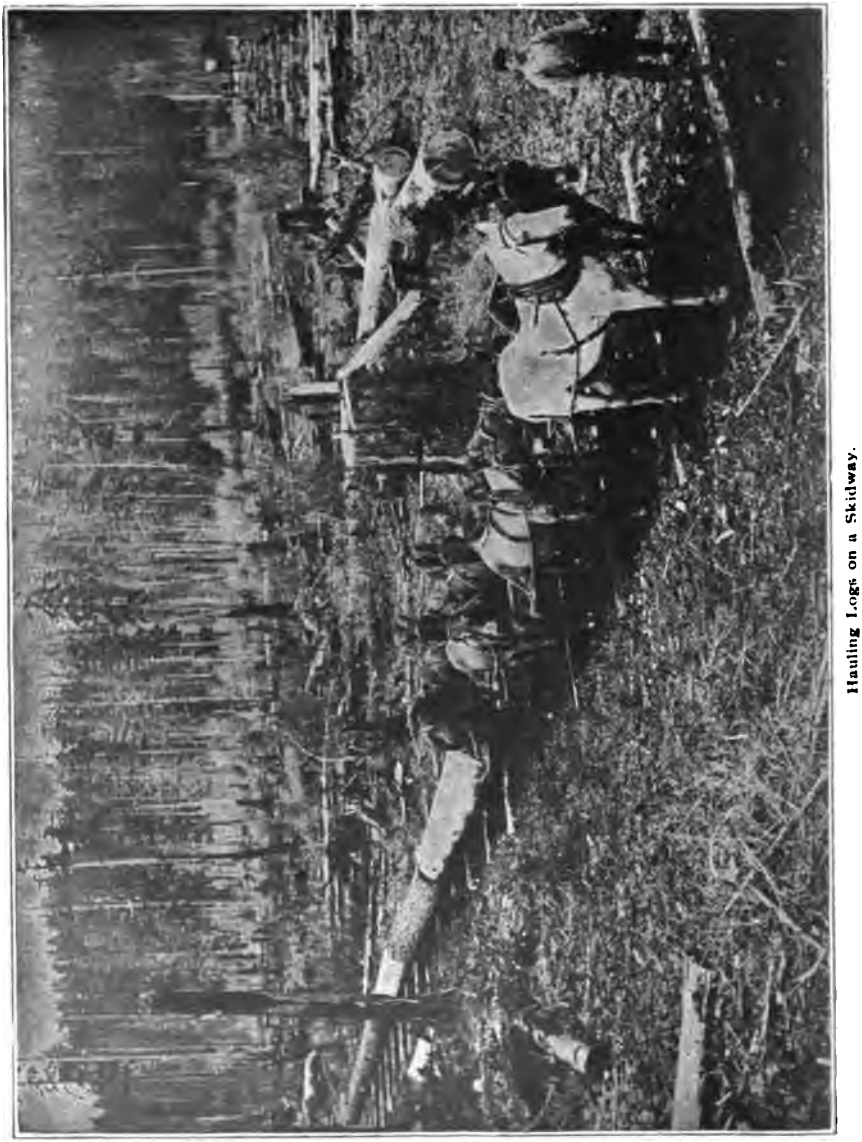
In cutting trees in the forest, felling is accomplished mainly by sawing from the upper side of the tree and chopping upon the lower side, meaning the side towards which the tree falls. After the tree is down, it is cut into lengths suitable for handling by means of great cross-cut saws in the hands of two men. It is astonishing how expert men become in severing huge logs, two of them cutting a three-foot log through in a few minutes, seemingly without undue exertion.

The first timber of a country is cut near the streams, because it is easy to float it out. As the cutting works farther away, the logs are sent on skids and flumes to the rivers, then light logging-railways are built, and finally, as the work is more and more removed from the water-ways, the hauling is done on established lines of railway, many railroads deriving a large part of their income in their earlier years from hauling logs.

In very many places, where lumber is cut on mountain slopes or the like, where there are streams, the lumbermen build a flume or rough artificial waterway, into which a stream is directed, the flow serving to carry down the logs. When there is plenty of water in the flume the logs go booming along at tremendous speeds to some place of deposit, usually a river. Probably the longest of these flumes is in the great redwood forests of California. It is fifty-three miles in length, and has, in addition, feeders or branches eighteen miles long. It is built of two-inch planks, arranged in V form, the width across the top being three and one-half feet. It cost $275,000 to construct, using 5,700,000 feet of lumber. A man at the tops of each of the feeders to start the logs, and a man at each junction, and one at the outlet are all the help required to operate this flume, which has a carrying capacity of 400,000 feet of lumber daily.

The traction engine has become an important feature in handling lumber on the Pacific coast. In sections where the traffic is

not great enough to afford the building of a railway, and there is no convenient waterway that can be used, the traction engine is employed on roads built largely for the purpose, and hauls lumber-



Hauling Logs on a Skidway.

cars at a speed of two or three miles an hour, taking as much as fifty or sixty tons of logs in a train. The route of the traction engine begins in the forest where the logs are cut, or where they are

dropped by a skidway, and the engine power is utilized to load the logs on the trucks which serve as cars, for it must be understood that a logging-car is usually nothing more than a pair of wheeled trucks, on which long logs can be carried.

One of the simplest and most useful devices of the lumbermen for handling logs is the skidway, which consists of logs laid on the ground in such fashion that other logs can be slid along them. The illustration shows one operated by mule power. In a steam log-skidding system a strong steel cable is suspended from two large trees, perhaps seven hundred feet apart, and upon this cable is a travelling engine, sometimes called a skidding engine. The logs are fastened with a hoisting rope assisted by grappling-tongs, and then the engine travels along, partially hoisting the log, whose forward end is swung into the air and dragged or skidded along the cableway to the point where the loading is done.

A slightly different method of hauling logs is employed in many Western sections. A skidway or runway being provided along which the logs can slide, a hauling-engine is located at one end with a drum and perhaps several thousand feet of wire rope. By this means the logs can be hauled easily and cheaply along the skidway, especially in the winter, when it is covered with ice. All lumbermen in the Northern States take more or less advantage of the winter season with its snow and ice, as affording means for running log sleds. A team of horses will haul a surprising number of logs along a road that in the winter season is smoothed over with ice, though quite rough in summer.

In swampy sections, as Louisiana, what are termed pull-boats are sometimes used, these employing endless ropes and winding drums, by which the logs are drawn out of the swamp to a place where they can be floated. When the logs are brought to a river, they are then usually floated down to form a raft. The handling of logs in rivers is picturesque and ofttimes dangerous, for when the logs jam together, stopping a stream, it becomes necessary for the lumbermen to walk over them and find the log or logs that require to be cut away in order to break the jam. When these are found, and the cutting begins, the lumberman must recognize when he has cut to the point where the log will break in another instant, and he must then run for his life.

When the logs reach some harbor on the ocean they are made into rafts, some of which are of enormous size. At Puget Sound a raft has been built so large that a force of men were kept busy for eight months in tying it together with chains, at a cost of $30,000.

A good deal of log-cutting and transportation is done without due regard to any future crop of timber. Often the snakeways for dragging out logs are more numerous than is necessary, and sometimes big logs are sent recklessly down a slope, killing off hundreds of tree-sprouts. A log three or four feet thick acquires tremendous momentum in going down hill, and is capable of cutting off and destroying fair-sized young trees. The young growth is more subject to damage in regions where there is no snow than in the colder climes. As timber becomes scarcer, more attention is being given to these evils, and popular sentiment and legislation are both directed towards the stimulation of tree-planting and general encouragement of tree-growing.

Considerable standing timber is annually destroyed by fire, some of these forest blazes being the result of accident, but more frequently resulting from the practice among farmers of burning over land in the fall, with the notion that this will produce better pasturage the following year. Such fires often spread to the forests on mountain slopes, and burn for days and weeks until extinguished by some heavy rainstorm.

Where an intelligent effort is made to preserve or improve a forest, and at the same time make it yield timber, success has met the efforts of the foresters. The least desirable growth can be cut out, giving more chance for the better trees to increase. An experiment made on the Biltmore estate, near Asheville, North Carolina, demonstrated that it was possible to secure 3000 cords of firewood annually from 4000 acres, and yet to improve the standing timber every year.

It is impossible to predict when the timber supply of the United States will be so depleted that various industries will begin to suffer from timber famine. There is no positive knowledge as to the supply in the country, nor do we know how soon public measures will be adopted that will tend to preserve and protect the forests. We do know that some sorts of timber are giving out, as native black walnut, which is no longer to be had; and first-growth white pine, which is scarcer every year; and that spruce fit for pulp wood will not continue to supply the enormous demands from the paper-mills. Notwithstanding, there is no general movement looking to the conservation of the timber supply, and the growing of new timber to replace that which is cut, yet the matter has been agitated and discussed, and the continued rise in the price of lumber will sooner or later have its effect and change conditions in the United States, as they have been changed in the older countries of Europe.

Over there enormous saw-mills are unknown, because there is no great timber supply in one place to feed them. When our timber is more reduced, the great saw-mills must fall away and be replaced by small concerns with a capacity suited to the regular annual production of the forests on which they depend. The mammoth milling plant cannot exist on a second growth of timber, because the adjacent land cannot produce enough large logs within a given number of years. It developed in this country because lumber concerns were able to gain control of large tracts of heavy timber, but as these are cut away, the death-knell is sounded for the milling plant, and the prosperity of a few years is sure to be replaced by stagnation for many years afterwards.

A Typical Western Lumber-Mill.

A fair illustration of the growth of American saw-mills is furnished by the mill at Lewiston, Maine, which is one of the oldest in the country. It was built in 1770 as an annex to a grist-mill, and later it was destroyed, but rebuilt in 1808, and enlarged in 1814. An entirely new mill was constructed in 1851 at a cost of $7000. This gave way in 1865 to a mill costing, with building, land, and tools, a total of $60,000. This mill was equipped with gang and

circular saws, and some approach to modern conveniences. To-day the Lewiston Steam-Mill Company has a large plant, which at a guess valuation is perhaps worth $200,000.

The Division of Forestry of the United States Department of Agriculture has given some attention to the testing of the physical properties of timber, with a view to determining its average strength for structural purposes. Some 45,000 tests were made up to 1896, when the work was interrupted; but it is expected that further tests will yet be obtained, as the Forestry Department in 1902 announced its intention of taking up the work again. These will be valuable, for as one class of timber begins to give out, and prices rise in consequence, builders have to substitute other kinds, and there should be a central source of reliable information as to all the native woods. Tests of this sort have been made in Europe at various places and times for more than a century.

For sawing logs into lumber the steam circular sawing-machine is universally used, but in place of the single large saw formerly employed, a double saw is now preferred, the log being carried against two saws set in the same plane, and cutting from opposite sides at the same time. This method has two advantages—the sawing is done more quickly and the kerf or cut made in the lumber is thinner, thus reducing the amount wasted in sawdust. One saw is set slightly in the rear of the other, so that their teeth may not clash, and they rotate in the same direction, though they cut in opposite directions on the log, as one is above and the other below.

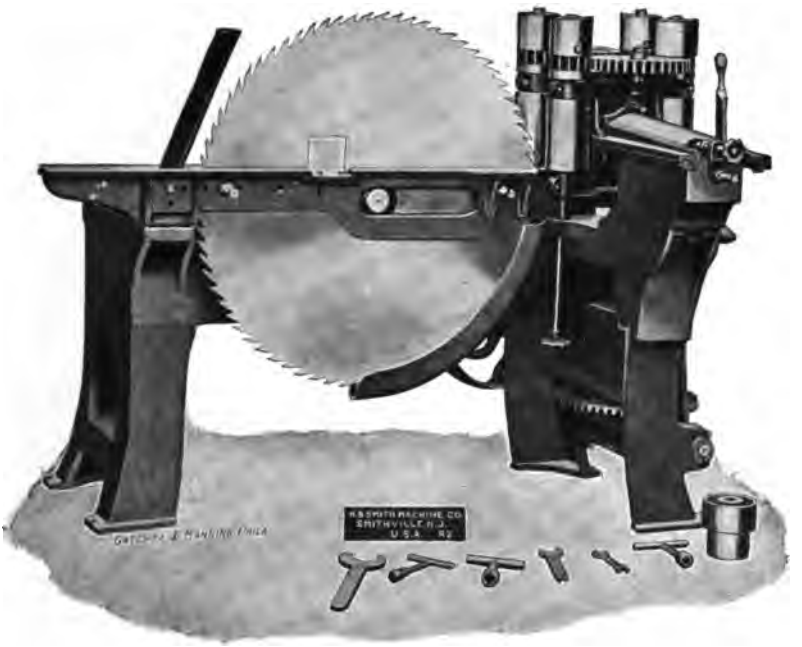
The machines that reduce the logs to the larger sizes of lumber are termed log-sawing machines, and those employed in planing-mills and by local lumber dealers to reduce their lumber to such smaller sizes as their trade demands are termed resawing machines. These are smaller and lighter than the log-machines. For miscellaneous and special work there are a hundred or more special forms of saws, only a few of which space will permit describing here.

When large circular saws first came into use much difficulty was experienced with them, owing to the fact that the outer edge was apt to become heated, so that the expansion and the centrifugal force together would cause the circular edge to break off. This difficulty has been overcome in a measure by hammering the circular saw throughout its central portion, the hammering being heaviest towards the centre, thus giving a tendency to expansion throughout the whole saw, and permitting the periphery to expand with heat, without breaking away from the rest of the saw.

The steam-feed has proven one of the most valuable improve-

ments that have been made in saw-mills in recent years; this type of feed has also been styled the shotgun feed. A long-bladed saw is attached directly to the piston of a steam-engine, the steam-cylinder for this purpose being made unusually long, so that the saw is given a long stroke, which may be very rapid. This principle has been adapted to several minor devices in the saw-mill, thus supplying the steam-power very directly to the work.

The various forms of planing-machines are mostly manufactured with rotating cutter-heads, which serve the purpose of a hand-plane in smoothing the lumber and bringing it to an even thickness.



A Single-Saw Recawing Machine.

For edging the cutters are short, and arranged to smooth the edges of boards or planks. The matching-machine is an edger with a device for tonguing and grooving the board. For forming ornamental or curved edges, moulding-machines are employed.

For the descriptions and illustrations of the following machines used in the planing-mill, and by wood-workers generally, the writer is indebted to the H. B. Smith Machine Company, of Smithville, New Jersey.

The flooring-machine is supplied with a fast feed, and not only dresses the lumber, but cuts the match or tongue-and-groove on the

edges of the boards. In the machine shown there is a chip-breaker placed before the cut, and this, together with the cutter-heads, is made adjustable. The feed is variable, owing to an ingenious

A Swing-Saw.

arrangement of friction drive. Planing- and matching-machines in great variety are made on very similar principles, the lumber being fed in between rollers and guided to cutters.

Machines for smoothing or planing lumber are known as sur-

facers, and the double surfacer shown is designed to finish wood for cabinet work; it can be used to feed many narrow pieces of stock

A Resawing Band-Saw.

at one time. A variety of other forms of cabinet and smoothing surfacers are manufactured.

Hand-planing machines are commonly known as jointers, and are built for the use of small carpenters, etc.

Machines for making wood mouldings, or panelling or profiling wood, are commonly known as moulding-machines. These

A Saw-Table

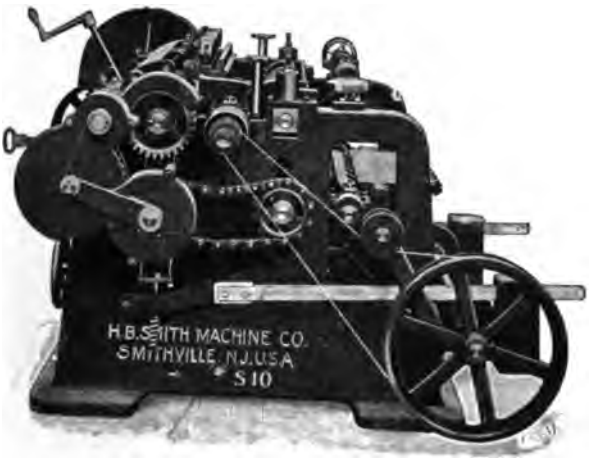
acomplish their work by means of peculiar forms of cutters. Many special moulding-machines are made for such work as cutting washboards, grooving window-sashes, and the like.

Wood-Moulding Machine.

Combined rabbeting-, beading-, and jointing-machines are made for the purpose of cutting lumber so that it can be joined by

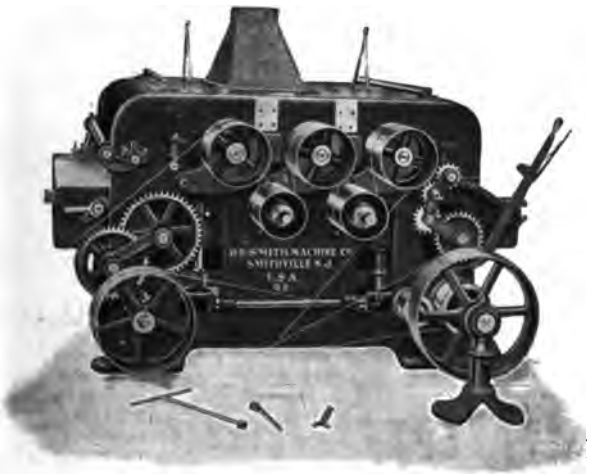
rabbeting—that is, by means of cut grooves or rectangular notches, a bead being cut at the joint.

One of the most recent improved forms of tenoning-machine



Double-Surfacing Machine.

for cabinet-makers is double ended. The cutter-heads are adjustable by a single screw for making any thickness of tenon. This machine will cut a piece of wood on both ends into any of a great variety



Triple-Drum Sanding-Machine.

of forms desirable in box-making or cabinet-making, for joining together.

A quadruple mortising- and boring-machine is manufactured

that, as its name implies, will perform four operations at one time, as mortising two slots and boring two holes. It is capable of cutting 3500 mortises, and boring as many more holes, in a single hour, and will work lumber as long as nine feet, making mortises three inches long if necessary. The upright mortiser is a favorite machine that is often made in combination with a boring-machine. There is also manufactured an endless-chain mortiser that cuts grooves with astonishing rapidity.

Among resawing machines the band type is popular, one being shown here that is made with metal wheels of fifty-four inches diam-

Fast-Feed Flooring-Machine.

eter, covered with rubber or the like to protect the blade and prevent slippage. When these are used on heavy work, a saw-deflector is added to keep the blade in line. A somewhat similar but lighter band-saw is manufactured for scroll-cutting. Straight saws are made for special work and for hand use. The jig-saw, hack-saw, and various small saws are of this type.

The gang ripping- and edging-machine is used in saw-mills for edging boards and planks and for sawing boards into flooring, joist, scantling, etc. A special machine is also manufactured for cutting laths and pickets in gangs.

For general miscellaneous work, as in a carpenter shop, the universal saw-bench is commonly employed, this being a table with a top adjustable to various inclinations, and having a circular saw protruding through the top. The swing-saw, which may be hung from a ceiling, is a very convenient tool, having numerous uses. Sand-papering machines, more commonly known as sanders, are made for smoothing wood, the sand-paper being attached to a wooden rotating drum; there are also special forms of sanders for special work.

Boring-machines are made in a great variety of forms, as are also routers. Special carving-machines are manufactured which will turn out a variety of rosettes and other geometrical designs for ornaments. For further information along these lines the reader is referred to manufacturers' catalogues of wood-working machinery.

IN THE BOWELS OF THE EARTH

THERE is nothing elevating about a mine except the hoist that takes one out of it. All the words in the language that suggest going below the surface indicate that it is an unpleasant if not a degrading thing. Man loves to rise and soar, and not to descend, grovel, sink, go down, etc. All the similes and suggestions connected with excavation and mining are of this "low" character. Yet there is no more romantic occupation than that of seeking after mineral wealth by mining. Coal-mining is desolate, dirty, and prosaic enough, but getting out the paying ore from a Comstock lode,

Courtesy The Macmillan Company.

A Mine-Shaft Station at Kimberley.

or plucking diamonds from a Kimberley bed, savors so strongly of riches as to fire the imagination and cupidity of the world.

When it was learned that there was plenty of gold in Alaska to be had for the digging, there were clerks who left their desks, artisans who dropped their tools, business men who cashed in their holdings, loafers, desperadoes, and all types of men in thousands who turned their faces to the new Eldorado and risked all on the chances of the future.

Gold is found chiefly in veins of quartz rocks, or in placer

deposits. The important gold-mining centres of the world are in Western Australia, the Transvaal, Africa; in Russia and British Columbia, and in the United States at Cripple Creek, the Black Hills of South Dakota, and in Alaska, California, Montana, Arizona, and Utah. The search for gold has ever been regarded as full of hardship and privation, since mines are discovered invariably in new countries, and the prospector is subjected to all the difficulties of accomplishing work in a territory where there is no established means of transportation and where machinery and supplies have to be brought from great distances.

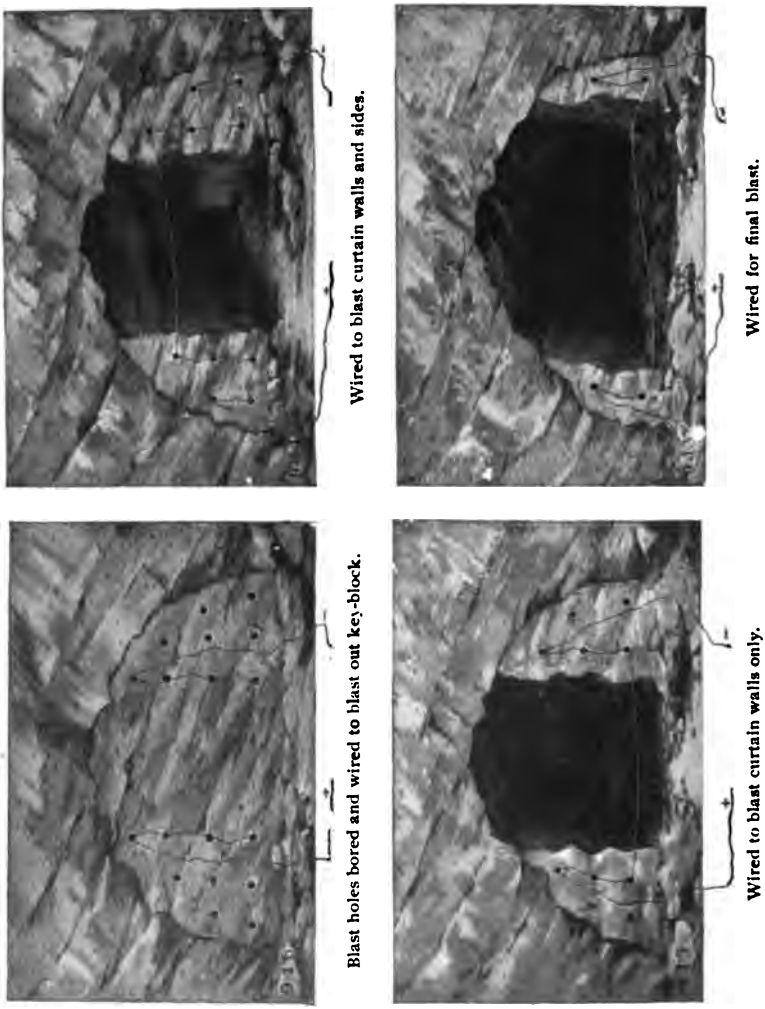
The largest single gold nugget ever found was picked up at the Kingowar diggings near Melbourne, Australia, in 1857 by Samuel W. Napier, who subsequently lost his wealth and died miserably in a Canadian lumber-camp. Napier and his brother were working a small 36-foot claim, and this is his own story of the find:

"We had got down to the pipe clay bottom, which marked the bed of an ancient river, when my pick struck something hard. I knew at once it wasn't a boulder, for there was not the same ring to it. It struck dead. Scraping away the dirt I caught sight of the bright yellow of pure gold. We were afraid that some one would learn of what we had found and rob us. We therefore covered it with loose dirt and sat down to plan. We discussed scheme after scheme until we worked ourselves into a great state of anxiety. We finally decided to borrow a tub and cautiously wheel it to our camp, taking turns at wheeling and agreeing that if any one spoke to us one was to stop and talk and the other was to wheel right along. Just about dusk we landed the nugget in the tent. We threw it under one of the low beds and sat down to wait until midnight. Early in the night we put out our light and pretended to go to bed. Instead, with pick and shovel we dug a hole six feet deep right in the middle of our tent; there we buried the nugget and filled in the earth so as to not leave a trace of our work. No one had seen the nugget but ourselves, and it was now buried six feet deep out of sight.

"But a nugget six feet deep was no use to us. We must get it to Melbourne. There was plenty of time for that, and, besides, there might be other nuggets in our claim. We went to work every day and left the tent open to avert suspicion. For three months the nugget lay there buried and at the end of that time we washed out our claim. We found a number of nuggets in the same hole, one of which weighed eight pounds. Armed with a shotgun and revolver, we started in a one-horse cart and in due time reached Melbourne. Next day we deposited the nugget in the bank and our fears were at an end. The news spread like wildfire and thousands rushed to the Kingowar gold fields. While in Melbourne we named the nugget the Blanche Barclay, in honor of the beautiful daughter of the governor, and by that name the model in the British Museum is yet known. The bank gave us an insurance of $50,000 for the safe delivery of the nugget in London, and we sailed for England.

"When we arrived the papers wrote up the story of the nugget and we at once became famous. The queen sent for us and we dined in Buckingham palace. We drove down from the Bank of England under heavy escort, taking the nugget with us. Her majesty and the Prince Consort received us most graciously, and the Prince of Wales, who was a lad of fifteen years then, showed a very deep interest in the nugget. I do not wonder at that, for it was one of

the prettiest sights one could see. It was 23.7 carats fine, or as nearly absolutely pure gold as is possible to get. Then the nugget was put on exhibition at the Crystal Palace, for which privilege we were paid $250 a week. We lived in a swell house on the Surrey side. This lasted for three months, during which time Sir Roderick Murchison had a cast made of the nugget for the British Museum. The work was so perfectly done by an Italian that you couldn't tell


Wired to blast curtain walls and sides.
Wired for final blast.
Blast holes bored and wired to blast out key-block.
Wired to blast curtain walls only.

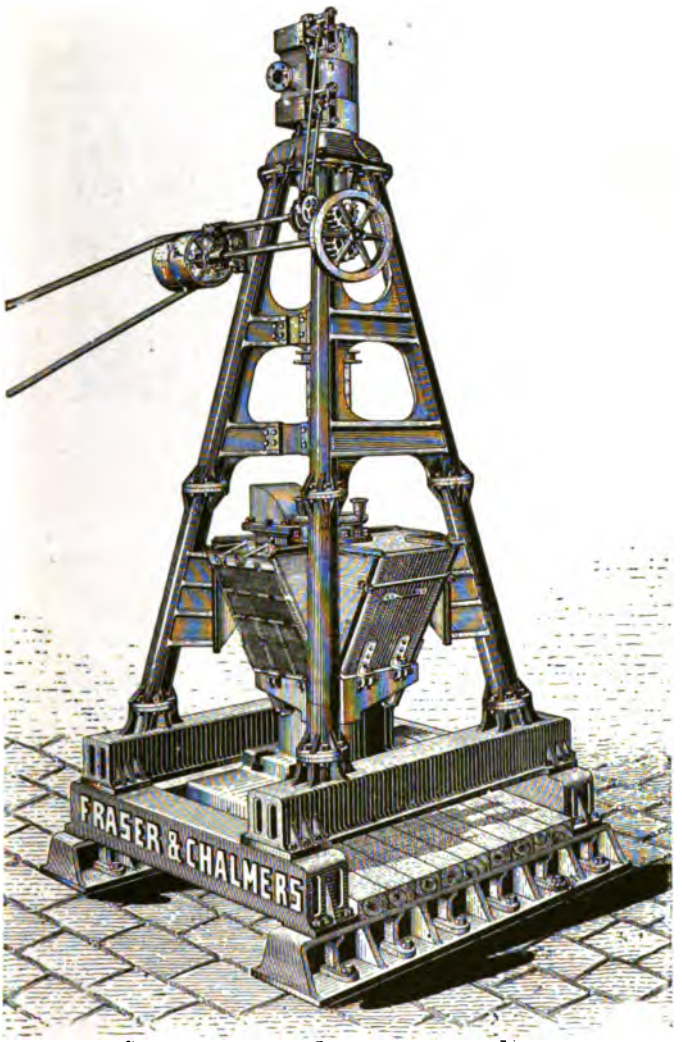
Illustrating Method of Boring and Blasting.

Courtesy Ingersoll-Sergeant Company.

one from the other until you lifted them. He gave me a duplicate. Finally we sold the nugget for $60,000. It was not worth more than $50,000 intrinsically, but being the largest and finest gold nugget ever found we got $10,000 more for it than its real value."

In order to afford an idea of what is required in mining gold or silver, it is well to enumerate the more important machinery

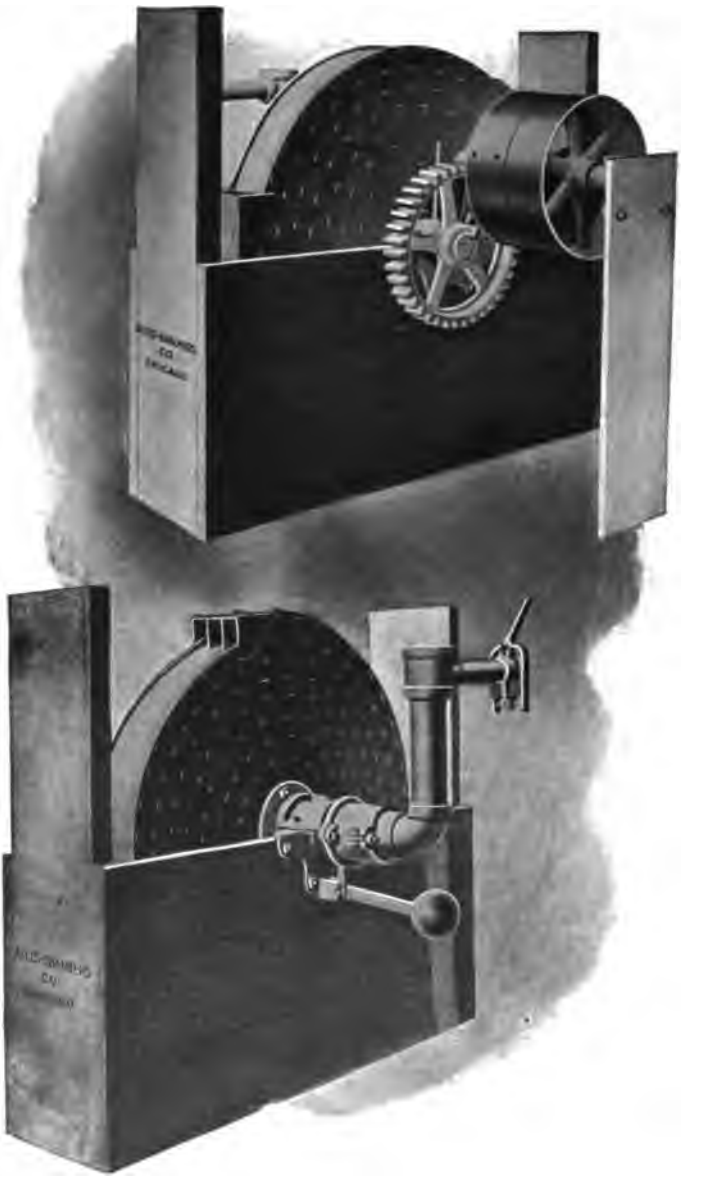
required for prospecting. A moderate outfit would be that for a three-stamp mill for use in prospecting. The stamps would be about 250 pounds each, operating in a battery driven by a little upright



A Steam-Stamp.

steam-engine. With these would be required a lot of duplicate parts, a complete set of water-pipes and valves, also rubber hose and a set of copper plates for washing, besides a lot of minor items. Such outfits are manufactured so that they can be taken apart and

transported on muleback, in order that they can be erected anywhere, regardless of roads.



Sand-Pumps.

When the prospector has developed a vein of paying ore, he requires very much improved machinery, and a good battery of

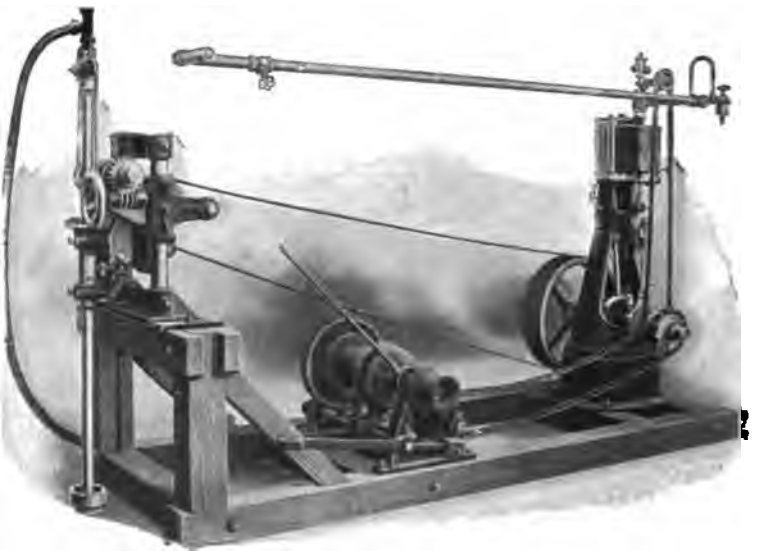
stamps or a steam-stamp are required for breaking up the ore, or, if it is a large mine, several batteries will be required. In a typical gold-mill the ore is rolled in on a tramway and dumped into the upper story of the mill, descending to the lower floors as it passes through the different processes of crushing, stamping, and washing.

In getting out the ore in the mine the process is simple drilling and blasting, but in successful mines there is a large amount of improved machinery as hoists, pumps, fans, air-compressors, etc. Compressed air is being used in many mines to operate drills and other tools, and has the advantage that the exhaust air serves to improve the ventilation. Considerable electric machinery is also coming into use. The large blocks of ore are crushed in a grizzly or other breaking machine, so that they are made small enough to be handled in the steam-stamp. The richer ore is most easily separated, and one of the important problems before gold-miners to-day is the extraction of all the gold from low-grade ores. There are two familiar methods,—the cyanide and the chlorination process. The cyanide process is not well adapted to the recovery of coarse gold, but is desirable in the treatment of certain auriferous ores. It is based on the chemical reaction resulting from contact of weak solutions of cyanide of potassium with gold in the presence of oxygen.

A rough idea of the process perhaps can be best obtained by giving a short description of the plant of the Dakota Mining Company. Here the ore is crushed with a solution of two pounds of cyanide to the ton. The pulp that comes from the batteries is raised by a great sand-pump to the launders feeding the separator-boxes, where the sands and slimes are separated. The slimes and the overflow go to the slime-vats, while the sands are discharged into other vats, where they are leached and then discharged into still lower vats. The sand-vats are charged once a day by the separator-boxes, and the pulp is leached with a solution of four pounds of cyanide to the ton, followed by a weaker solution of one-half this strength. The slimes are treated with a solution of slacked lime and allowed to settle, after which the pulp is drawn off at the bottom and there is another period of settling, more lime being added. This circulation and settling are repeated several times during a period of about one week. The precipitation is carried on in zinc boxes, from which they are sluiced to the acid-treatment tank, after which the metal is filtered, washed, dried, and smelted.

The chlorination process consists in charging the ore, after it

has been pulverized, roasted and moistened, into tanks, coated with tar, or sometimes lead-lined. These tanks have filter-bed bottoms, and after a tank has been carefully closed and sealed, chlorine gas is admitted to the ore, which it permeates, converting the particles of gold into soluble trichloride. After several days' treatment in the chlorine tank, the gold-bearing solution is directed to settling tanks, and the fine slimes are leached out, after which the top liquor is carried off to precipitating tanks, where the precipitation is assisted by the addition of ferrous sulphate, or hydrogen sulphide and sulphurous acid gases. When the precipitation is complete, the



Courtesy Diamond Rock Drill Company.

A Diamond Prospecting Drill.

liquid is drained off and the precipitate washed with hot water to free it from the iron salts. After this cleaning it is dried, and may be melted into gold bars.

The barrel process of chlorination is now often preferred to the vat process, which has just been described. In this lead-lined rotating barrels are substituted for the vats, and woven asbestos cloth is used for the filter.

Placer mining consists in washing out the gold from sand and gravel that have been washed down from ore-bearing rocks during previous ages. Where the ore is rich, gold can be recovered from the sand with the simplest sort of pan for washing, the weight of the gold grains making it easy to separate them from the sand; but

for working larger areas, where the percentage of gold is small, as perhaps twenty-five cents to the cubic yard, the best machinery is essential to securing a profit. Such gold-bearing sands are apt to accumulate in the bottoms of streams and rivers, and expensive dredges are necessary in order to gather the sand from the river-bottoms so that it may be passed through amalgamators, to save all the light fine gold.

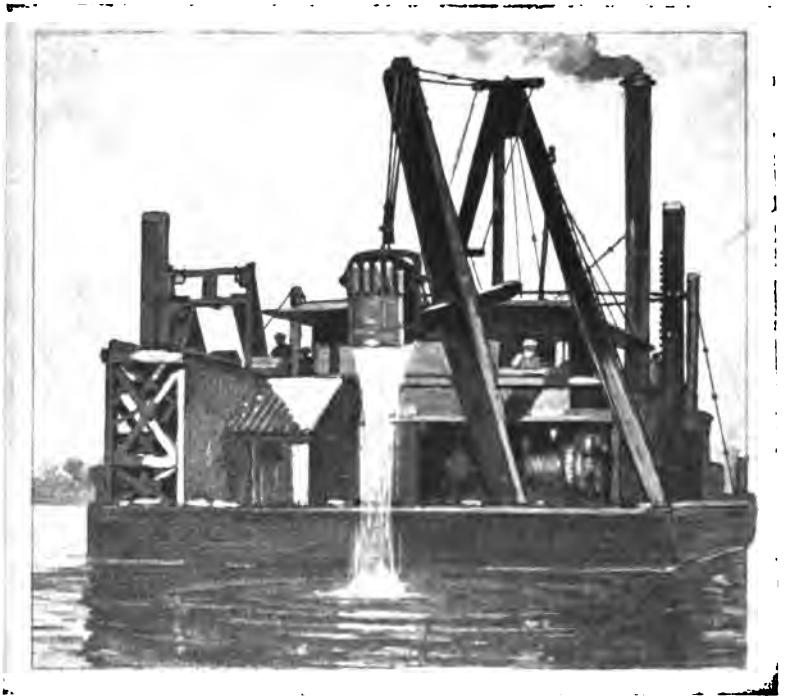
The Klondike fever came in 1897, and the fame of the Nome mining district followed in 1898. The Nome mining region comprises a mountainous section, including the greater part of the Seward Peninsula. The whole country has evidently been subjected in bygone ages to violent volcanic disturbances, as the rocks lie in planes at all angles, and faults, that is breaks in the direction of a vein, are extremely common. Gold is found in the gneiss and mica schists, but was first discovered in the beach sands.

An Electric Mine Locomotive.

The rush to Nome was at its height in 1900, when the population was 40,000; to-day the population is not over seven or eight thousand. Most of the crowd that arrived in that year found that everything that was worth claiming had been claimed, and that the richest deposits on the beach which were the easiest to secure were already beginning to give out. The claims staked and allowed at Nome were extremely large, running from 600 to 1300 square feet, but this was later checked, and no man was allowed to claim more ground that he could work.

The year 1899 was the best for taking gold from the beach, the $2,000,000 output of Nome in that year including rather more than one-half of beach gold. It is stated that $500,000 of this was taken out at Tupkuk in three weeks' time, and it is reliably reported that three men in that place picked up $36,000 off a small plot on the beach within three days. It was the reports of this sort of luck that brought the crowd in 1900, most of whom were doomed to severe loss and suffering.

California's output of gold has been materially increased during the past year by the success of the dredge system for recovering gold-bearing mud from river bottoms. On the Feather River meadows, below Oroville, in Butte County, some twenty enormous dredges are constantly at work, each raising from 2000 to 3000 cubic yards of mud daily. During 1903 they recovered about $1,000,000 worth of gold from this section, and probably the output will be nearer $2,000,000 in 1904.



River Dredge Operating for Gold-Bearing Mud.

The mud and gravel are dredged to a depth of from twenty-five to fifty feet below the natural river-bottom, and the mud pans out gold to the value of from seventy-five cents down to eight cents per yard. When it runs below eight cents, the dredges move in search of better territory. Several forms of dredge are used, some bearing an endless belt carrying buckets and others employing a great scoop or shovel. The mechanical system most favored is thus described by the San Francisco *Enterprise:*

"The screen is set on a grade, so that the heavy material gradually travels through it and is discharged overboard at the stern of the dredge. A perforated

water-pipe extends into the screen, the water at the rate of some 3000 gallons per minute thoroughly washing the gravel and finding its way with the gold and fine material through the perforations of the screen and into a distributing box; from thence it goes on to the gold-saving tables, which are divided into sections and are covered with cocoa matting and expanded metal. The excellence of these tables is shown by the class of gold saved on them, much of it being so fine that it can only be seen by the aid of a magnifying-glass. The water is supplied by a centrifugal pump, and the whole of the machinery on the dredge is run by a marine engine indicating less than 40 H. P.

"The dredge is handled by two men, one a fireman and the other a winchman. It is mainly owing to the excellence of design of the power winch that a dredge with the large capacity of 2500 cubic yards gross per day requires only two men on a shift to operate it. The winch has six barrels, four of these control lines running from the four corners of the dredge, the fifth carries the head line, and the remaining one raises and lowers the ladder.

"Attempts have been made to work these river-beds with suction dredges, but these have not been successful, as the high specific gravity of the gold enables it to escape from the suction when the cutter breaks down the pay dirt.

"Placer dredging is yielding excellent profits. One outfit with two dredges averaged a net profit of $600 a day for three weeks. It is estimated that there is now invested in California almost $3,000,000 in this branch of mining.

"At the close of a day's work the gold dredged has been separated from the gravel, and is ready for the mint at San Francisco."

No other branch of placer mining has ever yielded richer returns to the average miner, and the fact that the Oroville district is in the locality where Marshall first discovered gold in California, starting the famous rush of "forty-nine," is of marked interest.

Dredging is not confined to the Oroville district, being also employed on the Klematho River, and on the Trinity, Mokelume, Bear, and American rivers, the latter being a tributary of the Sacramento.

The production of gold in the United States as determined by the Bureau of the Mint from 1873 to 1904 was, in round numbers, 68,000,000 fine ounces, worth about $1,400,000,000. During the same period 1,375,000,000 fine ounces of silver were obtained, the production of silver having increased more rapidly than that of gold. The largest annual production of gold in the United States was for many years the $65,000,000 product of 1863. Since 1898 we have exceeded this every year, the product in 1902 being $80,000,000, which figure was very slightly exceeded by the mines of Australasia. In 1902 the total gold product of the world was figured at $295,000,000, and that of silver figured at its coining value at $215,000,000. The world's industrial consumption of gold in 1891 was $76,000,000, the United States being the largest user.

The thirst for silver is probably responsible for as many crimes as the thirst for gold. Since the time when Pizarro robbed the Incas of Peru and Cortés tortured Montezuma and his followers in

Mexico, the pursuit of the white metal is marked with a stream of blood as deep as that which has followed the search for gold and diamonds.

The United States produces the largest amount of silver of any country in the world, the famous Comstock lode being the richest

Courtesy Ingersoll-Sergeant Company.

Sinking a Small Shaft for Prospecting.

ever discovered. There have been found in this lode great bodies of ore containing as much as from sixty to eighty-seven per cent. pure silver. The Leadville mines rank next in importance, and there are also silver mines in Colorado, Montana, Nevada, and New

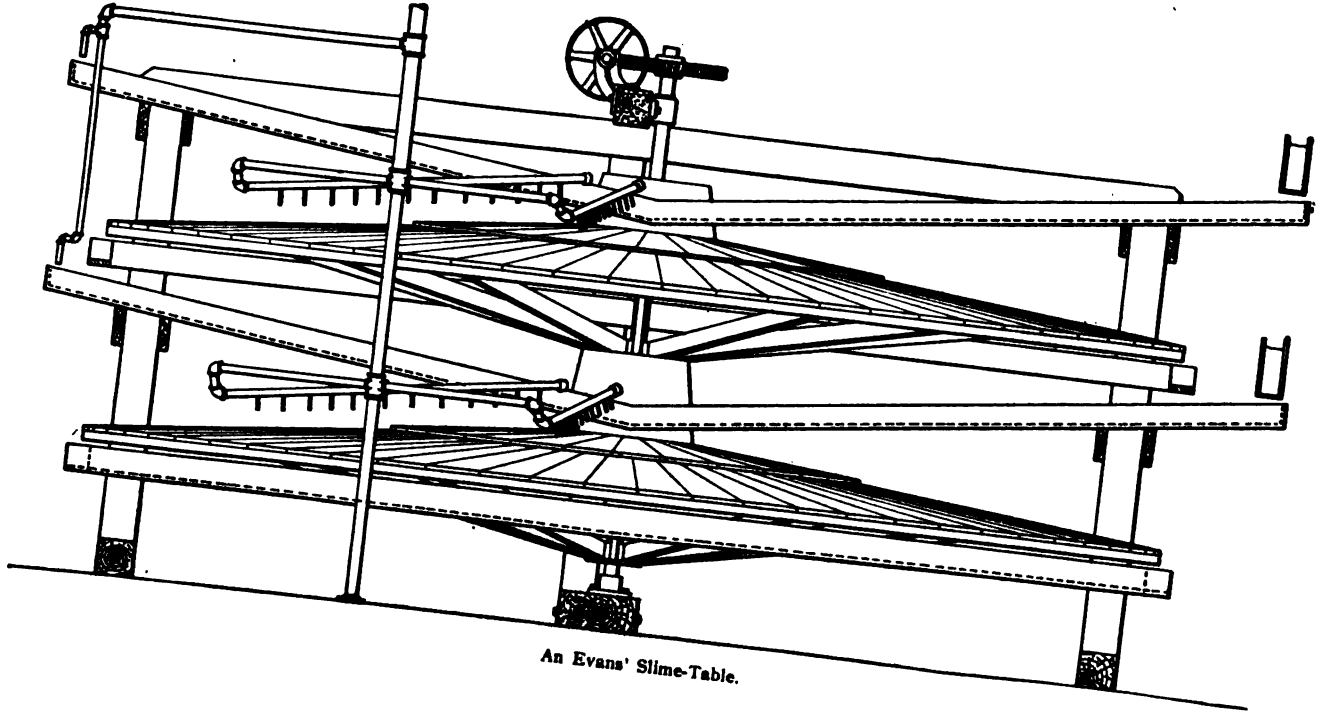
Mexico, while in Central and South America are a number of silver mines that have been producing for over two hundred years.

The mining of silver is not pushed as hard as it was in former years, owing to the fact that it is falling into disuse for coining into money, and this has so reduced the demand that the price of silver has declined steadily for many years, and were the owners of mines to increase the production rapidly the price would fall much faster than it now does.

Courtesy Ingersoll-Sergeant Company.

View in a Silver Mine.

In the Comstock lode the silver is found in quartz rocks; in Leadville silver and lead are found together in granite; in many other places silver is found in galena, usually in veins of quartz; in Eureka, Nevada, the silver is found in iron gangue. Like gold, silver is occasionally found nearly pure. At the Beaver mine on the north shore of Lake Superior as much as three hundred pounds of silver have been found in a single lump, and some ore was found that yielded $8000 worth of silver to the ton, but this ran out alto-



An Evans' Slime-Table.

gether in two or three years. A mine at Silver Islet, not far from Beaver, also yielded several large quantities of pure silver, but in a short time the workings gave out. An old mine in Peru is credited with yielding a solid mass of silver weighing 800 pounds, and then worth about $15,000.

The mining of silver and recovery of the valuable metal from the ore present problems very similar to gold mining. There is

A Harz Gigging-Machine.

an increasing tendency to establish the plant for smelting out the metal at the mouth of the mine, although in many cases ores are transported a considerable distance to a smelting plant. In treating medium or low grade ore, concentration is the first process; this consists in removing the earthy and refuse matter so as to retain little but the mineral. A common machine for this purpose is a mill in which the ore is received after the first rough crushing, and knocked around in a cylinder having hardened steel rollers that

pulverize the ore, water running through to assist the separation. Another form of separating machine is called a gig or gigging-machine; with this the ore is fed on top of a screen and shaken so that the heavier particles settle down, while the lighter parts move along with the flowing water. Several similar machines known as classifiers or vanners are also manufactured.

The leaching or lixiviation process consists in roasting ore with salt to convert the silver into chloride, which is dissolved in a solution of hyposulphite of soda, and then precipitated with sulphide of lime or soda, as a sulphide of silver, which latter is refined. All silver ores can be treated by this process except those that contain so much lead that they have to be smelted. A common form of furnace is the Brückner, which is used in roasting silver or copper ores. After roasting with salt, the ore is moistened with water and charged into leaching tubs. The leaching removes the soluble base metal salts. After the salts are removed the next treatment is with sodium hyposulphite, and then the silver is precipitated. The time required for silver leaching varies from eight to seventy-two hours.

Previous to the War of 1861–65 most of the world's silver came from South America and Mexico; but after the discovery of the great Comstock lode in Nevada, that State became the largest producer of silver. This remarkable deposit consists of a nearly perpendicular vein of decomposed quartz, and not only contains silver in a very pure condition, but considerable gold, iron, and sulphur. The unprecedented quantity of valuable ore in this lode stimulated the search for silver in other localities and was responsible for the discovery of many valuable mines. In very many of these copper is found in conjunction with silver, as at Anaconda, Montana. Most so-called gold mines yield some silver, while silver mines produce some gold. The two metals are very commonly associated. Copper also is frequently found with them. The Veta Madre mine in Guanajuato, Mexico, which has been worked for over two hundred years, produces both gold and silver in considerable quantities, and is the most famous of Mexican mines. Colorado, Utah, and Idaho are the largest producers of silver among the States of the United States.

Improved machinery and methods for recovering even small quantities of mineral from the ore have resulted in the working of many mines where the percentage of valuable metal would have been insufficient to pay a profit with the machinery in use twenty-five years ago. A few of these machines are described and illus-

Courtesy Allis-Chalmers Company.

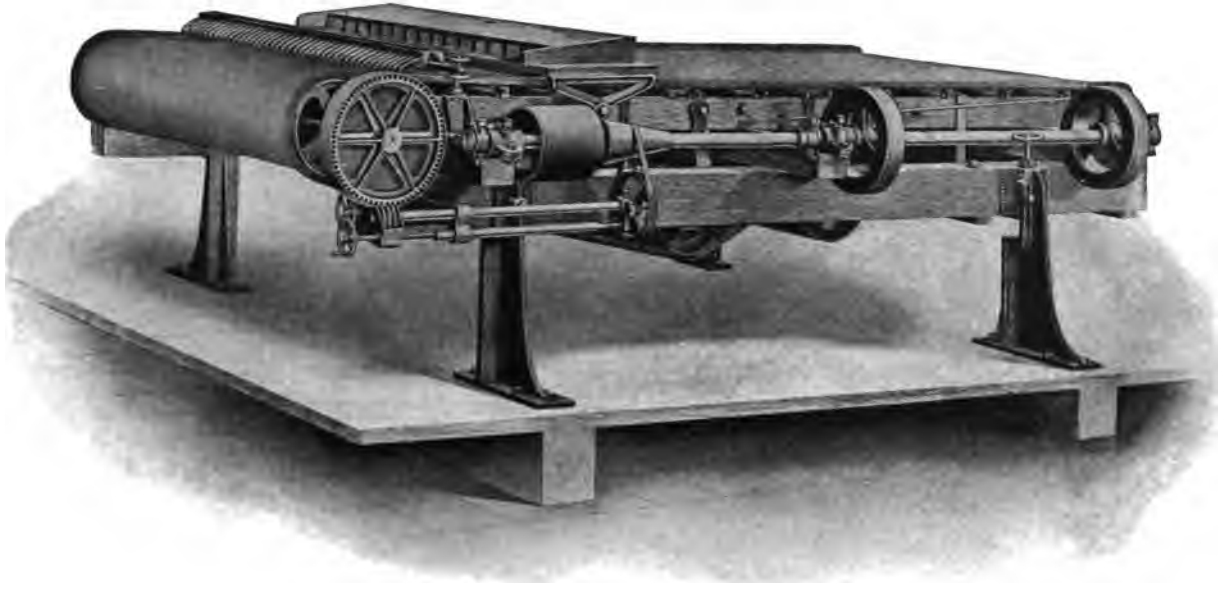
Group of Rotating Screens as arranged for the Wet Sizing of Ore.

trated here through the courtesy of the Allis-Chalmers Company. One is the spiral sand-pump, which is a decided novelty in pump construction, having neither piston, cylinder, cranks, valves, buckets, nor chains, and practically no wearing parts. It is simply a wheel, having openings in the outer edge, from which extend spiral passages round and round, in reducing diameter, until the centre of the wheel is reached, at which point the passages deliver into the pipe. This pump, being set to operate in a box to which are drained the sands of a concentrating plant, scoops up a portion of the sand and water at each revolution, forcing it onward and inward to the pipe. When run at a speed of twenty revolutions a minute such a pump will raise the material to a height of eighteen feet.

Screens for sizing crushed ore constitute an important part of coarse concentration, since the proper separating of the particles into sizes is essential to their farther separation by gravity; particles rich in mineral are heavy, and when placed with other particles of the same size in a gig or a slime-table or other washing apparatus are easily divided by their weight. The illustration shows a common arrangement of three rotating screens for the wet sizing of ore.

The ordinary type of gigging-machine consists of a water-tank divided with a partition that does not quite reach the bottom. The sized ore being fed on one side of the partition to a horizontal screen is subjected to the pulsation of water coming through the screen in response to the regular action of a plunger. This pulsation causes the heavier particles to settle down and discharge at a different place from the lighter particles. Classifiers are made in various forms, many of them being simply troughs having a series of boxes in the bottom through which the water and sand are made to pass, undergoing successive washings in each box, until the fine sand overflows at the outlet. In more modern forms compressed air is made use of for agitating the material, being introduced at the bottom of the classifier, and entering against the column of water that carries the sand. The Richard's patent vortex classifier, made by the Allis-Chalmers Company, has a cone at the bottom of the discharge-pipe under each box or vortex; this cone is so arranged that the wash-water is admitted with a tangential motion, which action prevents the slimes from passing down the discharge with the coarser materials, the classification being obtained by differing the pressure at the several vortices.

The Evans' slime-table, as used at the Anaconda mine, is a two-story affair, and the revolution of the tables carries around the



Courtesy Allis-Chalmers Company.

A Frue Vanner.

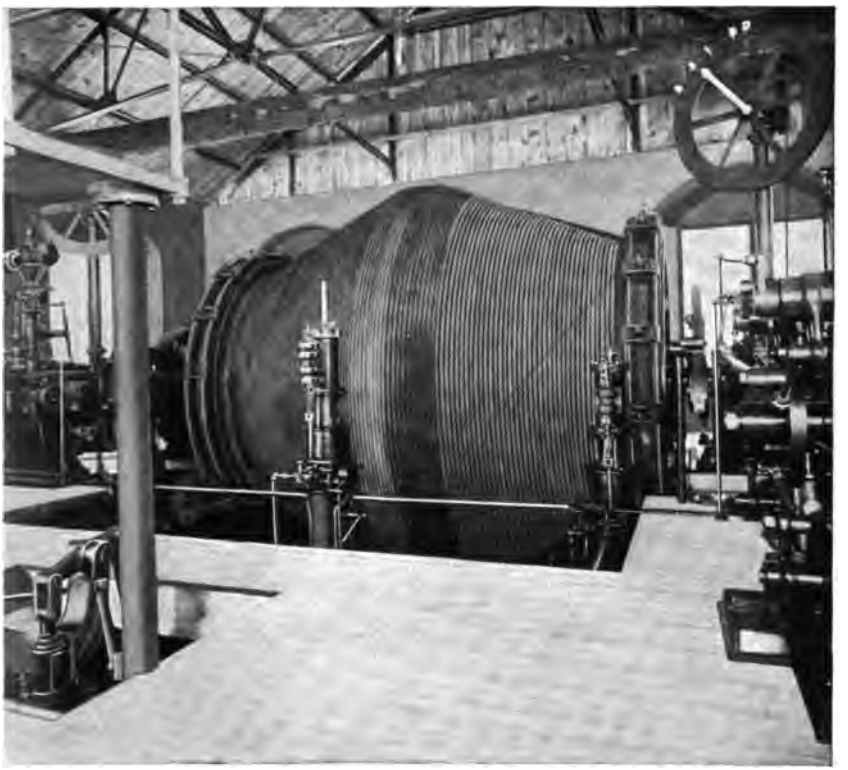
material deposited on them, so that it is washed by the water flowing down the slopes. The Frue vanner is a machine having an endless rubber belt supported on rollers so as to form an inclined plane. The belt travels up the incline and around a large roller into a water-tank in which the mineral is collected. The ore is fed upon the belt in a stream of water, and flows slowly down the incline, being subjected to a steady shaking motion, whose purpose is to deposit the mineral on the belt. Since the belt travels slowly, and the water jets wash in a different direction, the heavy mineral matter tends to stick to the belt and be carried over the roller or drum, while the lighter sand is washed off.

The largest deposits of copper ore are found in Montana and Michigan, these two States yielding more than a third of the world's total production of 525,000 long tons annually. Within a few years valuable deposits of copper have been found near the boundary of what is officially known as the Yale District of Columbia, including the Kettle River and Grand Forks mining divisions. In 1896 the Columbia Copper Company, Limited, of New York, was formed to push mining in this district on a large scale, and by the close of 1899 the Columbia and Western Railway was built into the district to render it available. There are now a number of companies operating in the field, which has proven quite rich, and modern machinery has been taken in to extract the metal from the ore economically. The Granby Company, of Phœnix, is one of the largest producers.

In smelting copper it has become common to use a process somewhat similar to the Bessemer steel process. A converter is used, which has a thick lining of crushed quartz mixed with clay. Molten copper matte is charged into the converter and air is then forced through the mass by a blowing-engine. The sulphur then combines with the oxygen of the air and passes off, while the iron is oxidized and unites with the quartz of the lining to form a slag, thus leaving the copper practically pure.

The hoisting machinery used in mines has arrived at a high degree of perfection. Since the lives of the miners depend in a great degree upon the correct action of the hoisting-machines and the pumping-engines that supply fresh air, these have received especial attention. The common type of hoisting apparatus consists of a high-grade modern engine operating a large drum bearing grooves, so that it serves to wind and unwind a strong steel-wire rope. This rope is attached to the cage, which is the name that the miner gives to what a "landsman" would call an elevator. The

illustration shows a conical drum-hoisting engine built by Frazer & Chalmers for the Atlantic Mining Company. At the ends of the drum will be observed steel band-brakes for use in case of an emergency, as the bursting of a fly-wheel causing the engine to race. The reason why the drum is coned so that the radius is greatest in the centre is because it is desired to counterbalance the weight of the rope when it is run out, so that the strain (or amount of work on the engine) is the same, no matter how much rope is



Conical Drum-Hoisting Engine.

hanging down the shaft. In a deep mine the cage is often moved at a speed that is very unpleasant to those riding in the cage until they are accustomed to it. Being dropped a thousand feet in considerably less than a minute is literally a hair-raising experience for one who tries it for the first time. In raising and lowering a cage in a mine, the engineer is governed by signals sent him from the different mine levels. There are also numerous automatic safety devices which prevent the engineer from causing difficulty below

by continuing to hoist or lower the cage when conditions may require a stop.

A common form of mine-cage is shown in the illustration. It is fitted with safety catches, arranged to work by means of springs, so that if the rope should break the catches are released and spring against one of a series of stout projecting stops mounted on the guides in which the cage slides up and down, thus supporting the cage at the point of breakage. The weight of the cage itself is utilized to hold these spring-catches out of action under ordinary cir-

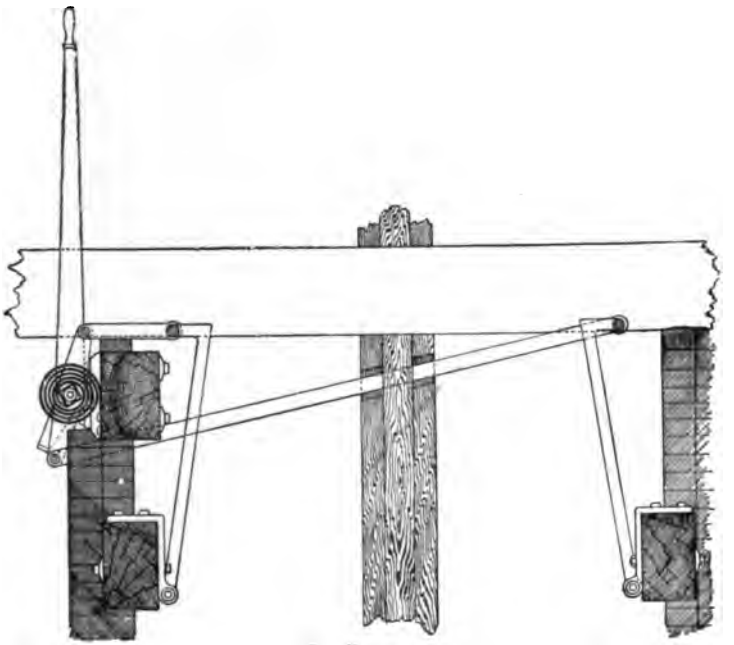
Courtesy Allis-Chalmers Company.

A Hooded Safety Mine-Cage.

cumstances; but should this weight be released by the breaking of the supporting rope the spring-catches would immediately fly out, stopping the descent of the cage. The tops of cages are often protected, like the one shown in the illustration, with a sheet steel roof that is peaked in order to deflect the blow of anything that might fall down the shaft on top of the cage. Another form of cage is made for carrying workmen's tools, having the sides and ends of the cage sloped inwardly towards the top, in order that long tools, such as crowbars, may not by any accident point outward and catch in the timbers or sides of the shaft, thus bringing about a dangerous accident.

At each level in a mine where the cage stops there are provided rests, called landing-dogs or chairs; the illustration shows a common form. By moving the lever in either direction the heavy cross-beam is shifted accordingly, so that it may come under the cage for a support or be moved away from it.

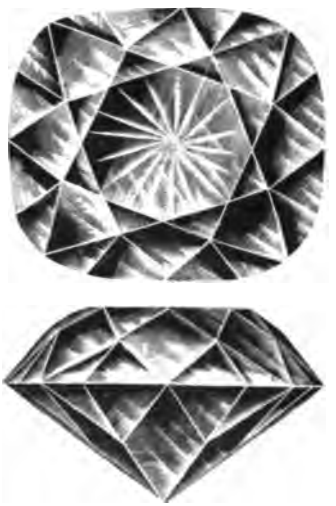
The speed with which hoisting is done in American collieries is illustrated by the records of the Nottingham shaft in the Wyoming Valley, Pennsylvania. It has two hoistways, and during the busy season there are sent up during every working hour 380 tons of coal, each trip of the hoist occupying less than a minute's time.



Landing-Dog.

Diamonds are said to be responsible for more crimes than any other form of human wealth. The simple fact that one stone may yield an ample fortune has been sufficient to tempt men to the commission of any deeds necessary to secure them. From the poor black, who gashes his leg and thrusts a rough stone into the flesh to sell it to some "fence," hanging around the diamond mines, for a tenth of its value, to the swell crook who burglarizes a safety deposit vault to capture the finished jewel, there is ever a hungry eye fixed on every one of the more valuable diamonds. The diamond fever is even worse than the gold fever, but the precious stones are found in so few places that fewer men are affected.

Within the past twenty-five years the diamond mines of South Africa have yielded gems to the total value of about $500,000,000, which valuation should be doubled to show the wholesale cost of the diamonds when cut. The final value of these stones, when they reach the public, would be several billion dollars. Previous to 1867 practically all the diamonds mined had been found in either of two districts, one in India and one in Brazil; but since the opening up of the mines at and near Kimberley, in South Africa, fully ninety-five per cent. of the world's product has come from the latter region. So prolific are these mines that it is only because of the wise forethought of Cecil Rhodes for the mine-owners that the price of diamonds has not been greatly reduced to the public through an oversupply.



The "Jubilee" Diamond.

The largest and finest diamond the world has produced came from Jagersfontein, in South Africa. This has been called the "Jubilee" diamond, and was exhibited as a product of French industry at the Paris Exposition in 1900. This unique stone weighs 239 carats, not only far outweighing other large diamonds, but exceeding them in quality, being of the best color and of absolute purity. There is not the least suggestion of a flaw to dim the brilliancy of its liquid light, and it glows with a limpid fire that is impossible of reproduction in an illustration.

Comparison with other famous diamonds is all to the credit of the Jubilee. The famous Kohinoor, belonging to the crown

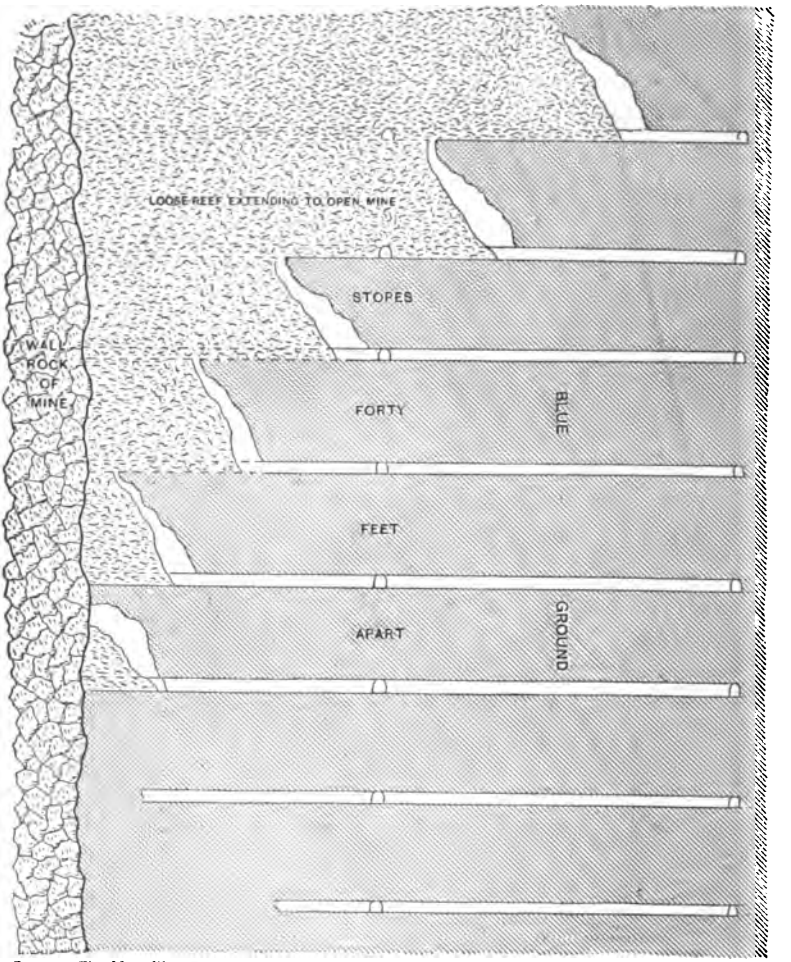
jewels of England, weighs 106 carats, and is slightly grayish in color. The Regent, belonging to France, weighs 136 carats, but

Ingersoll-Sergeant Drills Working in South African Gold Mine.

has a flaw in one edge. The great Orloff, belonging to the Czar of Russia, weighs 193 carats, but is yellowish and poorly cut.

For several years beginning with 1867 there were valuable

finds of diamonds in the vicinity of Kimberley, the most important of these being the picking up of the " Star of South Africa" in 1869, this being a pure white diamond of eighty-three and a half carats, which was bought by the Earl of Dudley for $121,250. By 1871



Courtesy The Macmillan Company.

Showing Method of Stoping in South African Diamond Mines.

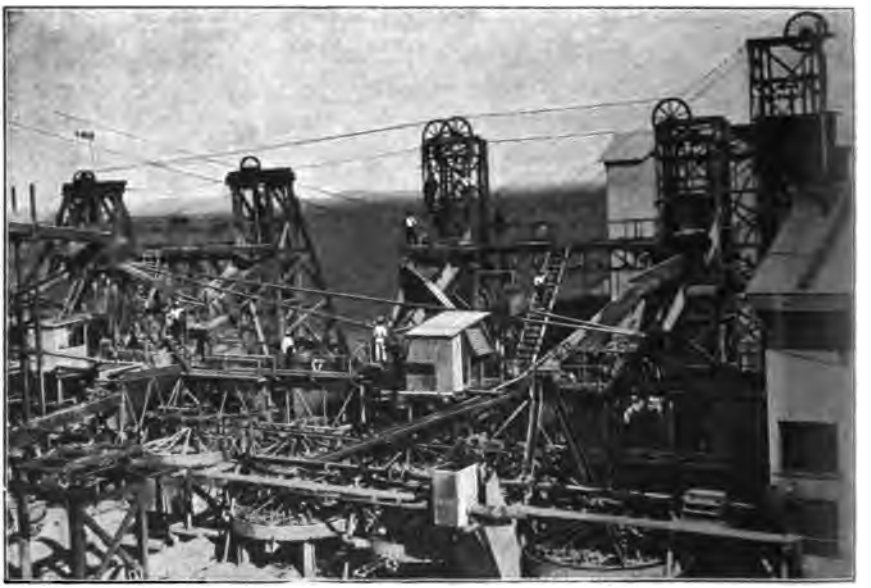
diamond mining was undertaken as a regular business at Kimberley, and claims were established very rapidly, each claim being thirty-one feet square. Within a few years there were discovered four productive centres, within a radius of three and a half miles. These have become known as the Kimberley mine, of thirty-three acres; the De Beers mine, of twenty-two acres; the Du Toit's Pan

mine, of forty-five acres; and the Bultfontein mine, of thirty-six acres. A smaller mine, the Wesselton, was located in the same district later, and at a distance of sixty miles there are the Jagersfontein and Koffeefontein mines. The Kimberley and De Beers mines are the richest, and originally consisted of over three thousand separate claims, but by 1885 the four principal mines had come into the ownership of forty-two companies and fifty-six individuals. Cecil Rhodes is entitled to the largest share or credit (if a credit it be) for consolidating the ownership of the mines; he began by organizing three firms into the De Beers Mining Company, and about the same time Barney Barnato took control of the Kimberley Central Company. These two companies continued to acquire more claims, and worked in opposition to each other until the competition brought the price of rough diamonds at the mines down to $4.32 per carat. It was then that Rhodes purchased Barnato's company outright, paying $25,882,292, which amount was covered by a single check, being the largest ever written up to that time.

In this South African district the diamonds are found mainly in what is called the blue ground, which exists in the form of pipes that run straight downward into the earth for an unknown distance. These are undoubtedly of volcanic origin, and the bluish color of the earth is due to iron, for which reason the same earth towards the surface of the ground is yellow, owing to the oxidizing influence of the air. This blue ground is hard, but at the De Beers mine is much harder than at Kimberley. To the touch it feels soapy, and there is a diamond in almost every cartload of it.

The first mining was done by removing the top soil, there being a red, sandy layer above the yellow earth, and enormous pits were dug, until a time came when the pits were so deep that the earth at the sides began to tumble in on the miners. Then the system had to be changed, and underground mining was begun in a manner very similar to the cutting of a coal-mine. Shafts were sunk and levels cut about every forty feet apart, the blue ground being taken out between the levels by stoping. The plan is to bore into the blue ground above the miner, taking it out in loads of about 1600 pounds, which are raised to the surface for treatment. Exposure to the weather softens the blue ground, rendering it much more easy to find the diamonds. There have, therefore, been established enormous floors on which the blue earth is spread for months in order that the weather may assist in crumbling it. For the protection of these floors, high barbed-wire fences are placed around them, while armed guards are on watch day and night, and search-lights are employed during the night to expose any intruders.

When the blue ground has been sufficiently weathered it is watered and washed in cylinders and pans, and subjected to various agitating processes. The final step is to pass the mud, as it may then be called, over a sorting machine, commonly known as a greaser. This is a stepped table having grease on each step; the rich mud is worked across the steps, and the diamonds have a tendency to adhere to the grease. So successful has this machine become that it secures nearly all the diamonds remaining in the material passed over it, less than one per cent. of its residue being passed on for hand sorting.



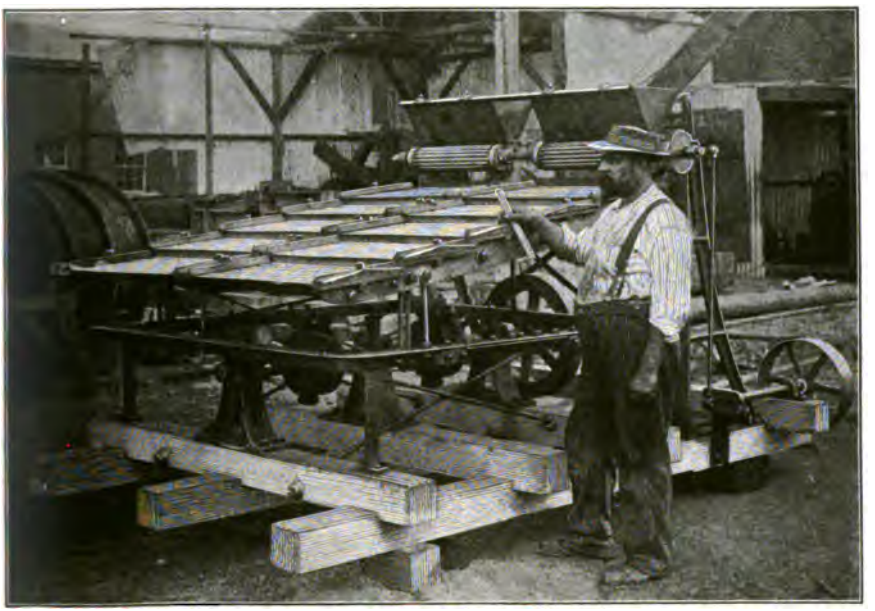
Courtesy The Macmillan Company.

A Washing-Plant in the De Beers Floors.

Of course a great many diamonds are found before the material goes to the greaser, premiums being offered to the men for finding diamonds in the mines and on the weathering floors. The white miner who finds a diamond in the mine receives seventy-two cents per carat, while if one be found by a black man he receives but twelve cents per carat. Diamonds found on the floor command a premium of one-half of these rates. Why the poor black is discriminated against to this degree it is hard to say. In addition to these commissions the best men receive very good pay, mechanics commanding $25 to $40 per week, miners $25 to $30, guards $20 to $25, machine men and assorters $25 to $30.

The cost of mining and bringing up each load of 1600 pounds of blue ground, including the entire handling and sorting of the same, is fifty-two cents, and each load averages to yield about one and a quarter carats at the Kimberley and De Beers mines; the average at the other mines is considerably less. The men work day and night in three shifts, and there has been built up around the mines a city having all the rough and boisterous characteristics of a mining centre.

Within recent years the mines have been fitted with the most approved type of modern machinery, mostly of American make.



Courtesy The Macmillan Company.

Diamond Sorter or "Greaser."

Here may be found Baldwin-Westinghouse mining locomotives hauling American-built trucks, also Allis-Chalmers air-compressors, Blake and Knowles pumps, Robins conveyors, Parsons steam-turbines of Westinghouse make, and a great variety of American electrical apparatus. The De Beers Company manufactures its own explosives for blasting, and owns a very large and up-to-date machine-shop used for keeping its machinery in repair. The Indwe Railway Coal and Land Company is a sub-corporation, largely owned by the De Beers Consolidated Mines, and not only doing a large general business, but supplying Kimberley with coal from the Indwe district.

The writer once met a man who said that he had the finest snap of any person in Pennsylvania. His job was shoeing mules six hundred feet below ground at $2 per day of ten hours in a Pittston coal-mine. This anecdote is of interest here as showing that there are some men who enjoy nothing better or can conceive of nothing more agreeable than working around the black ivory by the flickering light of a Davy lantern.

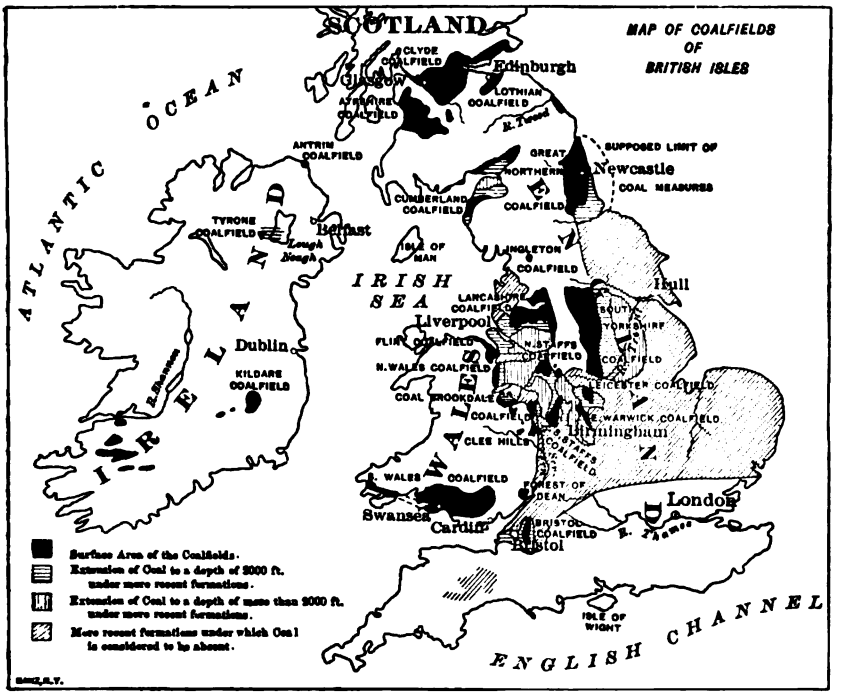
Jeffrey Locomotive and Mine Car.

Two common kinds of coal are mined, anthracite or hard coal, and bituminous or soft coal. The latter is the cheaper because there is more of it, and it is obtained in many more localities. The anthracite field of the United States is practically confined to Pennsylvania, where there is an area of 480 square miles, which produces between 50 and 60 million tons per year. It is also found in Rhode Island, Massachusetts, Colorado, and New Mexico, but is not mined to any extent in these States. Soft coal is found in large quantities in nearly every State in the Union, although more of it is mined in Pennsylvania than elsewhere, principally because the people of that State understand mining and have the best system for distributing the coal.

Until recent years Great Britain was the largest producer of coal in the world. It is probable that the coal-fields there were all deposited at about the same time, which is another way of saying that they are parts of the same field that have become detached by changes in the configuration of the land. Coal is found in large quantities in the North, in the West, and Midland sections in England, and in three districts in Wales, in seven districts in Scotland, and several in Ireland. The coal mined for burning under steam-boilers comes principally from South Wales, Northumberland, and to some extent from Scotland, Staffordshire, and Yorkshire; the Midland fields yield a coal that is valued principally for iron smelting, manufacturing, and for gas, coke, and house use. Some an-

thracite is found, especially in Pembrokeshire. The total annual production of the Scottish mines is about 33,000,000 tons; the great northern coal field of England yields 45,000,000 tons annually; the Midland fields 52,000,000 tons; the Lancashire fields 23,500,000 tons, while the other English coal-fields yield about 33,000,000 tons more; the Wales mines yield 32,500,000 tons, while the mines of Ireland produce the insignificant quantity of 100,000 tons per year.

In 1820 there were mined in the United States only 67,000



Courtesy Engineering Magazine.

British Coal-Fields.

gross tons of coal; by 1850 this product had increased to 7,500,000 tons, while the same year Great Britain mined 54,000,000 tons. We now mine 300,000,000 metric tons annually, a product unequalled by any other nation, the United Kingdom mining in 1901 223,000,000 tons, Germany 153,000,000, and no other nation as much as 50,000,000 tons.

In mining anthracite coal the method differs according to the inclination of the coal-bed. This may be either level or dipped; that is, set at an angle to the horizon. If a coal-bed is level and a hundred or more feet below ground, a perpendicular tunnel or

upright shaft is sunk to the bottom of the bed, and side tunnels or levels are cut into the coal, so as to carry it away. If the bed is in a hill or mountain it may sometimes be entered by a level tunnel, which is subdivided into numerous passages when the coal is reached. If the coal-bed be dipped or inclined, the main shaft may be run at the same angle as the dip, while the levels are cut lengthwise of the bed; this involves a very different equipment of cars and many differences in timbering.

The common way of taking out the coal is for the miner to bore holes into a breast or wall in front, then inserting explosives to blow out the mass. After the fumes have cleared away, laborers load the

Courtesy Engineering Magazine.

Coal-Miners Working a Longwall Face.

coal thus broken down into small cars, which are moved away, either by mules or by small locomotives, to the main shaft.

In the pillar-and-breast system of working a mine, the coal is got out in large spaces of perhaps twenty to thirty-five feet in width, these being called chambers or rooms. Each chamber is extended at right angles to a level or main gangway to a distance of perhaps 200 or 250 feet, after which the chamber is abandoned. Between each adjacent chamber a mass or pillar of coal is left to support the roof; side cuts are made between chambers, partly for ventilation and partly to get more coal. The Philadelphia and Reading Coal Mining Company uses a modification of the pillar-and-breast system, in which the chambers are made larger than ordinary,

thus securing more coal from a given area, but in place of every tenth or twelfth breast a block of coal of fifty to sixty yards across is left solid. By this means, if there is a fall or cave-in, it is always confined to a comparatively small space between one of these large supports. When a mine is practically exhausted, the cutting away of these supporting pillars is sometimes resorted to, this being termed robbing a mine. It is not only exceedingly dangerous for the men engaged in it, but often produces disaster on the surface above, through the sinking and settling of the soil.

An important modern improvement in anthracite coal mining has been brought about by the process of slushing, which is the

Courtesy Engineering Magazine.

A Modern British Colliery.

filling-in of the worked-out portions of a mine with refuse material. The method of operation consists in boring holes from the surface to the worked-out place that is to be filled. The sides of the section to be slushed are blocked and barricaded to prevent the slushed material running beyond the desired territory. The refuse from the mine-breaker is moved by scraper-conveyors to the entrance of a bored hole, where it is mixed with water and run down. The water serves to carry the refuse along to its destination, and the surplus water runs out through the crevices in the barricades, and is pumped out of the mine along with other water. A weak section of an old mine slushed in this manner can be filled and packed very

tightly. The town of Shenandoah, Pennsylvania, which some years ago showed signs of subsiding, was saved by this method of filling up the mines below.

A Jeffrey Coal-Cutting Machine.

Anthracite coal is not in condition to go to the public the instant it comes out of the mine, requiring first to be taken to a breaker, where the slate and other impurities are removed, and

where it is graded into the several sizes. Slate-picking is done principally by boys, but machines known as coal-jigs and slate-separators are coming into use, being practicable for smaller sizes of coal. These separate the coal from the slate by taking note of the difference in weight of the particles, somewhat after the manner of an ore-separator. The coal treated in these machines has the advantage of being washed in the jigs.

Anthracite coal is commonly preferred for consumption because in burning it gives out much less smoke and gas than the bituminous. Some railways use it exclusively in order to render their line more attractive and comfortable to passengers; on the other hand, large furnaces, iron mills, and steam vessels have largely abandoned the use of anthracite.

In opening bituminous coal-mines in the Pennsylvania region a survey is first made of the district, locating all out-croppings, that is, places where the coal comes to the surface, and recording the different levels between these points. This survey determines the best direction for driving the main gangway of the mine. When possible the main gangway is entered at a low point in the coal and carried up a slight incline, so that the mine will drain itself of water; but it is only occasionally that this is possible. The dip is not usually great, but the nearer level it is the less are the hauling expenses after the mine is in operation. Most of these mines in the Pennsylvania district are entered by drifts, having double and sometimes triple entry-ways, parallel with each other, and with only a supporting wall of coal between. As the drift is cut in, a light railroad is built, wooden rails often being laid at first until the mine work is established, after which light iron rails are laid. What is known as the double-entry system is now commonly employed in cutting the main gangways. Two entries are cut into the coal, parallel with each other, and eight or ten yards apart, and rooms are cut on either side as the work progresses; "break-throughs" are cut between the entries at short distances for ventilation. This system has the advantage of enabling more coal to be taken from a given area than any of the old systems.

The *World Almanac* for 1904 gives the following estimate of the amount of coal in the world:

"The coal-fields of China, Japan, Great Britain, Germany, Russia, and India contain apparently 303,000,000,000 tons, which is enough for 450 years at present rate of consumption. If to the above be added the coal-fields in the United States, Canada, and other countries, the supply will be found ample for 1000 years. Improved machinery has greatly increased the yield per miner, and thus produced a fall in price to the advantage of all industries."

MODERN FOODS AND FOOD PRESERVATION

WHILE we all eat to live, yet the man who lives to eat has a better chance of enjoyment in this twentieth century than he did a few generations ago. The many new foods introduced to tickle the palate and the numerous delicacies of all seasons, preserved so that they can be obtained at any time, have enabled the modern epicure to set his table at moderate cost with the choicest viands. Strawberries and ice cream may now be eaten in December quite as well as in July, while the season for the oyster has disappeared along with the seasons for special game.

It is to the modern methods for the preservation of foodstuffs that we owe in great measure the lengthy bills of fare provided by our hotels and restaurants, as well as the long list of canned goods furnished cheaply by every grocer. The use of ice and cold-storage facilities have done much towards keeping foods, but the canning industry has done a great deal more. It is now a little over one hundred years since Nicholas Appert, a Frenchman, brought into use the hermetically sealed glass jar for preserving fish, fruit, and the like. His method was that commonly practised by housewives thirty or forty years ago in boiling the food they could not use at the time and closing it up while hot in air-tight glass jars.

As an industry, Ezra Daggett and Thomas Kensett began the preservation of fish and oysters in New York about 1818, and a little later William Underwood and Charles Mitchell started a similar business in Boston, also putting up pickles, sauces, jams, and jellies. Kensett patented the use of tin cans for preserving in 1825, and started a little factory, but the manufacture of cans was slow and expensive at that time. The stamped can invented by Allen Taylor came out in 1847, and was improved a little later by Henry Evans, Jr., of New Jersey. By 1860 there were a number of canneries engaged in putting up lobster, mackerel, fruits, and vegetables in the State of Maine, but the canning industry did not become an active one until about 1870 or 1875, when the canning of fruits developed very rapidly. A closed process-kettle for cooking the fruit with superheated steam was brought out in Baltimore in 1874 by A. K. Shriver, and John Fisher, of the same city, invented another form of process-kettle about the same time. About 1876, an exhibit of the Ferracute Manufacturing Company, at the Centennial Exposition in Philadel-

phia, of tools for making cans and canners' goods, assisted a boom in the business, and canneries were established very rapidly wherever there were small fruits or fisheries.

The United States census returns of 1900 show a total of 2195 establishments engaged in the canning of fruit and vegetables, fish and oysters, etc., eighty-two per cent. of these being devoted to fruits and vegetables. The total capitalization was almost $50,000,000. While the fish and oyster canneries were so much fewer in number, the amount of money invested in that branch of the industry

Cutting Out Tops for Tin Cans.

was two-fifths of the total, the establishments being larger in character. The industry gives employment to a little over 50,000 wage-earners according to the census of 1900, but, as a matter of fact, the number of workers employed in the busiest month of the year, September, amounts to about 117,000, while there are nearly as many employed during August and October. July and June are also fairly busy months, although the busy season proper is usually figured from the 1st of July to the last of October. Before the fruit is ready for canning there is a month or so of busy work in making

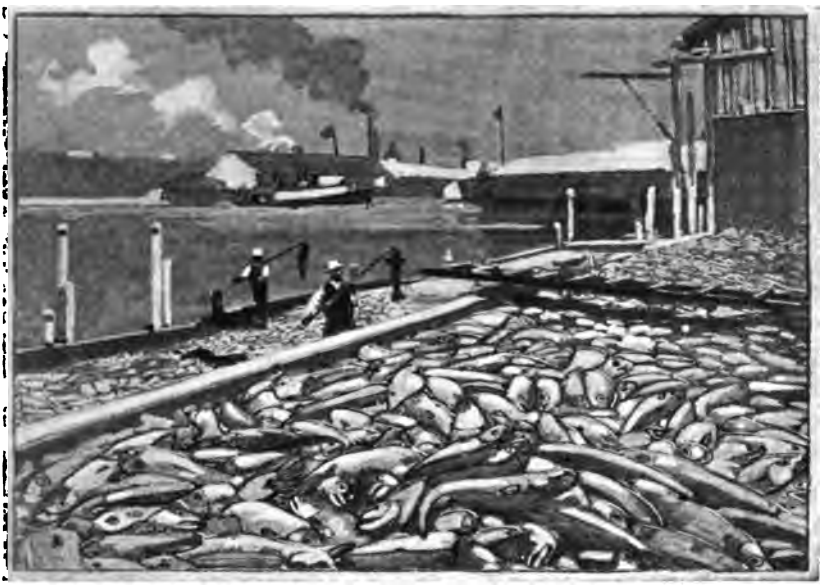
cans and preparing for the rush, and after the rush is over there is considerable final work in the way of labelling, packing, shipping, and selling for the winter market.

During the period from 1890 to 1900 the fruit and vegetable canneries more than doubled in number, the increase being mainly in the States of New York and Maryland, which lead in the industry, although almost every State in the Union is represented by one or more canning factories. In 1900 the cost of the fruit, vegetables, fish, oysters, etc., used by the canneries amounted to over $53,000,000, while their value after preserving was raised to nearly $83,000,000.

The process of canning fruits as usually carried on involves the use of steam-boilers for heating water, to supply the tanks and kettles, some of the tanks being used for washing and others for scalding. Baskets made of heavy galvanized wire are used for tomatoes and similar fruit, in dipping them into the scalding kettles. For steam-cooking a number of cans with soldered tops are placed on a tray and lowered into one of the great cooking boilers; the cover of the boiler is then closed, and steam turned on for the cooking. There is a little hole left in the top of each can for the escape of air and steam. When the cooking is finished the cans are hoisted out of the boiler, and a drop of solder placed on the hole seals the can so that there is no opportunity for germs to enter and cause decay.

Among the other tools of the canners are gasolene fire-pots for heating the capping-steels and tinning-coppers, or tools for closing the cans. These fire-pots are provided with air-pumps for driving air into the gasolene tanks, thus forcing out the oil to the fire-pots, where it is vaporized and burned as gas. Capping-tables are provided on which the fire-pots are placed, and here the cans are capped. Among the special machines made for the canner are hulling machines that will handle one thousand bushels of peas in a day, and rotary separators that will grade into sizes six hundred bushels of peas per day; also pea-sieves for sorting peas in small quantities, and pea-blanchers for scalding and blanching peas. Then there are corn-cutting machines that will remove the corn from the cobs at a speed of four thousand ears an hour, and corn silking-machines that remove the silk and other refuse from the cut corn, and automatic can-filling corn machines having a capacity of 12,000 cans a day. There are also several forms of machines designed for handling tomatoes, pumpkins, and other common sorts of vegetables, and a great variety of parers, graters, corers, and seeders.

Salmon canning is one of the most important branches of the fish-canning industry, and is largely carried on in California and the Pacific coast. A number of canneries also have been located in Alaska. The Chinese perform most of the labor in the Pacific salmon canneries, the method of operation being first to wash the fish and place in ice-cold water to keep them fresh and cool; next they go to the dressing-tables, where the heads, fins, and tails are cut off, and the carcass cleaned. After another washing they are cut into sections of a proper size for the cans to be filled, and after filling the cans go to the cooking-room, where the treatment is such



Salmon Fishery at Portland, Oregon.

that the fish is not only thoroughly cooked, but the bones are reduced to a crumbling condition.

The first cooking is done in a closed can, which is then punctured to let out the steam, after which there is another cooking, and then the can is sealed and given a bath in lye to remove the grease and dirt. On the eastern coast of the United States sardine canning is an important industry. The name sardine is applied to a variety of small fishes not over ten inches in length, and they are very commonly fried in oil and canned in an oily solution. Maine has by far the largest number of fish-canning establishments, there being 117 in the census year, out of a total of 348 in the United States.

The total value of the fish canned in the United States during the census year of 1900 was about $21,000,000, the total in pounds being 173,000,000 of canned fish, 22,000,000 of smoked fish, and 126,000,000 of salted fish. The salmon come first in value and weight, being followed by the sardines, these two being more than half the total quantity of fish preserved in the country; smoked herring come next in value, and then cod. The weight of the cod is in excess of the weight of sardines, but the value is less. Herring is the only other fish that cuts any considerable figure in preserving, and oysters and clams are about on a par with herring.

The preparation of meats for food has passed very largely out of the hands of individual butchers into those of slaughtering establishments and meat-packing houses. In the abattoir, or slaughter-house, the method of utilizing animals for food has been rendered quite economical. In the case of pork the animal is driven into a pen, and a cord being tied to one leg, the creature is strung up and attached to a pulley travelling on an overhead rail. As it passes along the rail it is stabbed with a promptness as humane as it is effectual, and then dropped into a tank of scalding water for the purpose of loosening the hair. It is picked out of the hot vat by automatic arms and deposited upon a table, where the carcass is scraped and the skin washed clean. Next there is an inspection to determine whether the meat is of proper quality, after which the carcass is cut open and the entrails removed, the leaf lard being taken out and placed in one pile, while the heads and tongues are deposited elsewhere; then the carcass is split into halves, which are run into the cooling-room.

The method followed with beef is very similar. The blood obtained in slaughtering is coagulated and used for sizing paper, and also in the manufacture of fertilizers, and for the refining of sugar. The blood of a steer ordinarily weighs about forty pounds, and sells for about $40 per ton. The undesirable and dirty portions of fat and meat are gathered and sold to manufacturers of soap, candles, and axle-grease. Such of the bones as do not go with the meat are disposed of to manufacture of glue and gelatin. The hair of the beef may go into "camel's"-hair pencils or serve as shoddy in the manufacture of "woollen" goods. The horns are made into knife-handles, umbrella-handles, articles imitating tortoise shell, whalebone, and a variety of smaller things. The bile goes to the bookbinder or painter, while the stomach of the young calf furnishes rennet used by the cheese manufacturer. The hog's stomach is the chief source of pepsin, and a variety of minor uses

are made of portions of the remains which would be thrown away by small butchers.

One of the largest industries growing out of beef slaughtering is the manufacture of oleomargarine, which is made almost wholly from a good quality of beef fat, that is chemically very similar to butter and equally wholesome.

The pork-packing industry assumed some importance about 1870, and beef-packing followed a few years later. At first these industries were carried on principally during the summer season. When refrigerating processes were introduced a few years later, the dressed beef as well as pork concerns experienced a boom. Between 1880 and 1890 the growth of the meat-packing industry nearly doubled.

Grain Awaiting Shipment.

Since 1890, while the industry has continued to grow at about the same rate, there has been a tendency to concentration of establishments, resulting in a lessening of the number, which is now below one thousand, with an average capitalization of over $100,000 for each establishment. In the census year of 1900 the total invested capital was $190,000,000; there were 69,000 employees; the cost of the animals slaughtered was $684,000,000, which was increased to $786,000,000 as meat.

Chicago is by far the most important centre of the meat-packing industry, Armour & Co.'s establishment being probably the largest in the world. They do a business of probably more than $10,000,000 a month, employing some 5000 railway cars to carry their products.

Kansas City is the next place of importance, and the industry there has developed very rapidly. South Omaha, Nebraska, is also becoming a large centre for meat-packing.

Our exports of pork and hog products constitute the third largest item of merchandise sold to foreign countries. In 1903 we exported over $112,000,000 worth, while other meat and dairy products footed up another $67,000,000.

The past fifteen years have witnessed a great change in the methods of producing cheese, butter, and condensed milk. Formerly these dairy products belonged wholly to the farm, but now the cheese-making industry has established itself largely in factories, while nearly one-third of the butter produce is also factory made. The following table gives a correct idea of the dairy situation in the census year of 1900:

Cows kept for milk, on farms, number	17,139,674
Cows kept for milk, not on farms, number	973,033
Total number of cows kept for milk	18,112,707
Milk produced, on farms, gallons	7,266,392,674
Milk produced, not on farms, gallons	462,190,676
Total gallons of milk produced	7,728,583,350
Butter, made on farms, pounds	1,071,745,127
Butter, made in factory creameries, pounds	420,126,546
Butter, made in urban dairy establishments, pounds	827,470
Total pounds of butter made	1,492,699,143
Cheese, made on farms, pounds	16,372,330
Cheese, made in factories, pounds	281,972,324
Cheese, made in urban dairy establishments, pounds	662,164
Total pounds of cheese made	299,006,818
Condensed milk produced, pounds	186,921,787
Value of total butter made, at 18 cents	$268,685,845
Value of total cheese, at 9 cents	26,910,614
Value of total condensed milk	11,888,792
Value of total cream sold	4,435,444
Value of total sundry factory products	1,261,359
Value of total milk consumed (estimated)	277,645,100
Aggregate value dairy products of United States	$590,827,154

There are now over ten thousand establishments engaged in the manufacture of cheese, butter, and condensed milk, and these have a capital of about $40,000,000 and give employment to about

13,000 individuals. Between 1890 and 1900 the capitalization increased nearly 300 per cent., while the products increased over 400 per cent. The creameries have increased in number even faster than cheese factories, and New York State has the greatest number of both, Wisconsin being second, and Iowa third. The reason why the cheese factory has swept aside the farm in the manufacture of cheese appears to be that it has succeeded in making both a better and a cheaper article, having a superior equipment and conveniences for making on a larger scale, as well as for selling and shipping. The business has gradually drifted into the hands of the factories, some of which keep cows, but, as a rule, purchase most of their milk from the farmers. The early cheese and creamery factories were

Discharging Wheat from a Vessel to a Lighter.

co-operative concerns, in which farmers were joint owners, but as the business developed and it became apparent that the handling of milk and cream, as well as the manufacture of cheese, was essentially a different business from raising cows and producing milk, the creamery as well as the cheese factory became a separate institution. The introduction of machines, as the cream separator or dairy centrifuge, had a considerable influence in developing the creamery. Having the best facilities for separating the cream, of course butter-making naturally seeks the factories, and the present indications are that within another ten years at least half the butter making of the country will be carried on in the creameries, and that farmers will devote their attention more wholly to the production of milk to be sold directly to the creameries.

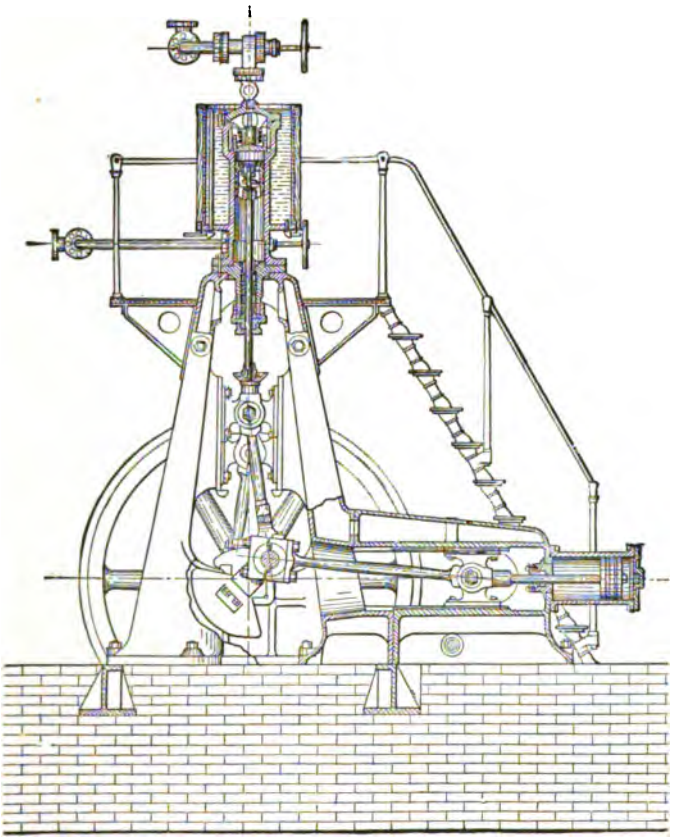
Another important development in modern foods is the marketing of a variety of cereals, produced under copyrighted names, as wheatena, force, shredded wheat, etc., these and similar articles being partially or wholly cooked, so that they can be eaten with very little preparation. These have largely taken the place of the old-fashioned corn-meal, cracked wheat, and graham mush, and to some extent have replaced oat-meal. As a table food their convenience and utility have made them a market, and the profuse way in which they are advertised indicates that they will increase in number and variety rather than be reduced by competition.

The modern bakery has modern machinery. One of the new devices is a dough-mixer capable of handling six barrels of flour at once. This machine has a spiral blade rotating in a trough. From this the dough is run into the kneading-machine, called a "brake." The common type of cracker-making machine receives the dough under a flattened roller at one end, a coating of flour being applied to the dough as it is pushed in. The flattened mass of dough is carried along to a travelling apron under a rotary brush that removes the surplus flour, and then to a series of stamps and dies that cut the dough sheet into crackers of the desired form. Advancing a little farther, the crackers are pushed down through the sheet of dough by means of mechanical fingers, while the surplus scraps are carried away to be used over again. The separated crackers fall into another travelling apron, and are carried to the baking-pans. Such a machine will manufacture about 50 barrels of crackers daily.

The preservation of meats and fruits for use at all seasons would be largely impractical were it not for the development of cold storage. Artificial refrigeration has grown out of the sale of natural ice, which was at first imported from the northern portions of the United States, especially from Maine and northern New York, until ice became established as a necessity in well-regulated households. Ice was first used in New York City for the preservation of goods about 1815 or 1820, and about the same time the sale commenced in the large cities of the South. The natural ice trade reached its height about 1870 or 1872, at which time the refrigerating ice-machines began to affect the sale of the natural article.

There has been a total of about 4500 patents granted in the United States for various processes of refrigeration, some 700 of these relating directly to ice-machines. The first practical ice-machine was that of Carré, a Frenchman, who patented his invention in the United States in 1860, founding what is known as the ammonia absorption process. Modern machines are manufactured

on his absorption system and also on the compression system. In the absorption system a solution of aqueous ammonia is employed, being first generated as a gas, then condensed, and then allowed to expand and absorb the heat. In order to understand the principle, the reader should bear in mind that ammonia boils at a very moderate temperature, 28½° F. It is therefore very easy to convert it



Sectional View of the Frick Company's Ice-Making Machine.

from the liquid form into a gas, and this change raises the pressure of the ammonia very materially; then by leading the ammonia through pipes that are kept cold by flowing cold water, the ammonia can be condensed again.

The compression system, having proved more convenient, is the one more commonly used. In this anhydrous ammonia—that is, ammonia which contains no water—is allowed to expand into a gas, and is subjected to pressure by means of a steam-pump. This com-

pression increases the heat of the ammonia gas, and by then passing the ammonia through coils of pipe and making it again cold—in other words, robbing it of its heat—the ammonia is reduced to a condition where it seeks to regain its heat. By allowing it to expand in pipes that surround a tank of water, the ammonia reduces the temperature of the water in its effort to regain its lost heat, and, by continuing a circulation of expanding ammonia around the tank of water, after some hours it is brought below a temperature of thirty degrees and becomes ice. The process is the same in cooling rooms to a temperature of, say, fifty degrees for moderate cold storage.

McGowan Steam-Pump.

In making artificial ice two forms of ice-tank are used, one being called the can system and the other the plate system. In the former, the water-cans are placed in the cool brine, these cans being of the size of the cakes of ice to be produced; in the plate system the ice-tanks are often five by ten feet and one foot thick, producing a large plate of ice, designed to be cut up for consumption. In the can system the water is frozen from all four sides to the centre, and both air and impurities are imprisoned in the cake, while in the plate system the air-bubbles and impurities rise naturally and leave the ice transparent.

During the period from 1870 to 1880 the number of establishments manufacturing ice in the United States increased from four to thirty-five, and produced a little over a quarter of a million to a little over a half a million dollars' worth of ice. During the next decade the number of establishments increased from thirty-five to 222, and the value of the product was raised to almost $5,000,000. The census returns for 1900 show that there were then 787 establishments, having a capital of nearly $40,000,000, and manufacturing nearly $14,000,000 worth of artificial ice per annum. Nearly two-thirds of the businesses are incorporated companies, and, strange as it may seem, the Middle States have more than twice as many ice-making establishments as the Southern States.

The manufacture of ice is peculiar in the fact that the materials used do not go into the product sold. The water of which the ice is made costs practically nothing, the largest item of expense in ice-factories being coal for producing heat to drive the compressors. In the year 1900 the coal bill of the ice-factories constituted two-thirds their total cost of operation. This has produced the very curious result of manufactured ice being produced almost wholly by the use of heat. The most expensive article used by the ice-factory is ammonia, but, as this is used over and over again, it does not constitute a very large item in the annual bill of expense, being an item rather to be added to the cost of the plant.

While the above summary of changed conditions in the food market is necessarily incomplete, yet it serves to show the principal changes that have developed with a generation, altering very largely the character of the foods eaten by the great public.

The writer cannot forbear in closing to call attention to the great extent of adulteration employed in many of the foods commonly offered for sale. There are no reliable statistics in regard to these, but it is a matter of common knowledge that manufacturers of foods are governed almost wholly by commercial considerations rather than the nutritive qualities of their goods and the health of the consumers. Unless there is brought into being some system of governmental examination and restriction as to adulteration, there cannot fail to be a continual increase of dyspepsia and diseases of the digestive organs. Boards of health and local officers already exercise some supervision over the sale of pure meats and some vegetables, as mushrooms, and it would be wise legislation to extend this control in a way calculated to check injurious adulteration.

HOW WE OBTAIN DRINKING-WATER

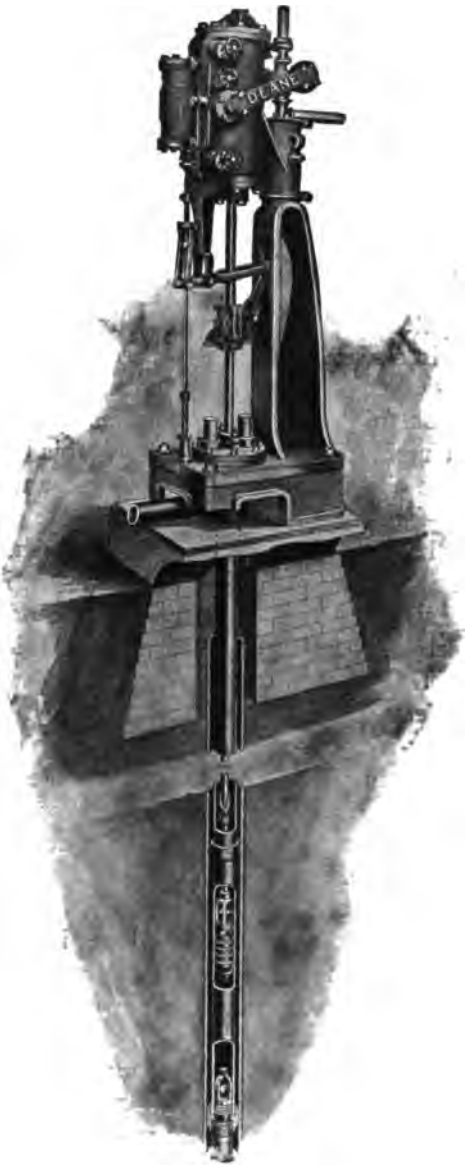
THE citizens of ancient Rome knew how to lead water from a source to a fountain, public bath, or the like. True, they had no proper pipes, but they constructed conduits that served the purpose, and carried the water to the dwellings of the rich. During the eighteenth century wooden and leaden pipes were used to a considerable extent, cast-iron pipe coming into use towards the close of the century. There is therefore nothing new in storing water in reservoirs and distributing it through pipes to the dwellers of a city. Even small towns now have their water supply, and the more pretentious country residences or estates, situated at a distance from a city or town, provide minor works for their private use.

There has been material advance in methods, however, and residents in cities never drank as pure water as they generally enjoy to-day, nor have they ever before enjoyed such thorough protection from fire as comes from the modern adequate water supply. Hydraulic engineers and boards of health have learned how to test drinking-water and provide for its purity before it is tried on the public, and cases of epidemic caused by bad water are now rare. Water supplies are commonly subjected to both chemical and physical tests to determine the nature of the impurities and their harmful character. The tests are made for solid matter, chlorine, and free and albuminoid ammonia. Forty grains per gallon of solids is not considered an objectionable quantity for the water to carry along, but if there are five or more grains of chlorine per gallon, it is necessary to look out for some sewage contamination. A single grain of chlorine per gallon is usually caused by vegetable contamination not of a serious character. Albuminoid ammonia indicates the presence of animal matter, as does free ammonia. A fifth of a grain of iron is not a cause for disquiet, nor a tenth of a grain of lead or copper.

The New Jersey State Board of Health has issued the following directions for making simple tests of the purity of drinking-water:

"COLOR.—Fill a clean, long bottle made of colorless glass with the water; look through the water at some black object; the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or solid matter in suspension.

Odor.—Empty out some of the water, leaving the bottle half full; cork up the bottle and place it for a few hours in a warm place; shake up the water, remove the cork and critically smell the air contained in the bottle. If it has



The Deane Artesian Engine and Pump.

any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that otherwise does not appear.

"TASTE.—Water fresh from the well is usually tasteless, even though it may contain some putrescible organic matter. Water for domestic use should be perfectly tasteless, and remain so even after it has been warmed, since warming often develops a taste in water which is tasteless when cold. If the water at any time has a repulsive or even disagreeable taste, it should be rejected.

"As some waters of dangerous quality fail to indicate their impurity either by smell or taste, what is known as the Heisch test is of value: Fill a clean pint bottle three-quarters full with the water to be tested; add to it a half-teaspoonful of clean granulated or crushed loaf sugar; stop the bottle with a glass stopper or a clean cork, and let the bottle stand in the light in a moderately warm room. If in twenty-four or forty-eight hours the water becomes cloudy or milky, it is unfit for domestic use. While cloudiness in the water after standing certainly indicates unfitness for use, yet a negative result does not prove the water to be good; because the test often fails to indicate organic matter really present, if phosphates are absent."

The best system for storing and delivering water is to dam up some mountain stream, forming a reservoir or lake, into which adjacent farmers are not allowed to drain, and to pass the water through filter-beds, piping it in iron pipes of large size to the consumers by simple gravity. Obviously this is impractical in many cases; some cities have to depend on river water, and not all can secure never-failing sources of supply at the desired elevation. Where pumping has to be resorted to, there is a choice of methods: the water may be pumped to a reservoir, whence it is fed by gravity through the pipes, or it may be pumped to a stand-pipe, or it may be pumped direct into the mains. Pumping to a reservoir is the best of these methods, as it insures a storage supply in case of drought or accident to the pumping machinery. Pumping to a stand-pipe or water-tower is resorted to usually in cases where there is no high ground on which a reservoir can be built. Pumping direct into the mains is a method resorted to only to save a large present outlay, and is a dangerous method, because of the chance of failure in case of fire.

The amount of water used from a supply in extinguishing fires is small in comparison to the total use, but it is quite as important in its way, for in a city the certainty of the water supply is the only safeguard against the spread of a fire. In providing for fire protection, the mains are made larger than is required for ordinary house service or manufacturing use, because the fire-hydrants may demand a large supply of water in a short time, and, as they also require a good pressure, the mains are generally strengthened with this object in view. A section of water-main, say 1200 feet long, and supplying sixty dwellings, would involve ordinarily a consumption of about 600 gallons of water daily; but if four fire-hydrants are placed on four street corners to draw from this pipe, and the

fire department takes a stream from each, a delivery of 600 gallons *per minute* will be required in place of 600 per day, and in this case a six-inch pipe drawing water from both ends is required for the service.

Cast-iron pipe is the sort commonly used for water-mains, though galvanized wrought-iron pipe finds some use, and lead pipe

Stand-pipe, Brooklyn, New York.

is generally preferred for service-pipe—that is, the pipe connecting the mains with the pipes in the buildings served. House-pipes are also commonly of lead, which is convenient, because of the ease with which it can be bent. As a rule, the lead does not damage the water for drinking purposes, although, where water has not been drawn from lead pipes for several days, it is best to let it run before using, For the use of those who fear lead pipe, it is often tin-lined. Con-

nection of service-pipe with street mains is made, without loss or leakage of water, by means of drilling- and tapping-machines specially designed for the purpose. What is known as a corporation stopcock is used to connect the main- and service-pipe, and where the service-pipe enters upon the building line is usually another stopcock, where the water can be turned on or off.

For the protection of water-mains against too great interior pressure, which might burst them at times, pressure relief-valves are made, which act automatically when the pressure reaches a certain point, and let off sufficient water to reduce the pressure. The accumulation of air in water-mains is avoided by air-valves, that collect the air at certain elevated points and discharge it from the mains.

Modern stand-pipes for holding water so as to give a pressure in the mains are made of steel-riveted pipe of very large diameter, frequently twenty-five or thirty feet, and often over a hundred feet in height. A cheaper construction consists of a tower of steel girders, bearing a water-tank on top.

For pumping water in connection with a reservoir or tank system, any common type of steam-pump may be used, but where there is a very large amount of water to be pumped triple-expansion engines are preferred. A description of the twin engines installed at the Baden pumping-station of the St. Louis water-works will suffice to give an idea of what they are like. The contract provided that these engines should each have a capacity of 10,000,000 U. S. gallons in twenty-four hours. The three cylinders are of 64-inch stroke, and the high-pressure cylinder is of thirty inches diameter, the intermediate cylinder fifty-four inches, and the low-pressure cylinder eighty inches diameter. They are vertical, and have single-acting plungers. To retain the heat, the sides of the cylinders are jacketed, and on top of the jackets and over all other heated surfaces is a coating of two inches of magnesia and two inches of hair felt enclosed in wood lagging. Corliss valves are used, and the governor controls the cut-off of the high-pressure cylinder. There are two piston-rods to each cylinder, connecting to a four-cornered crosshead, having the connecting-rod in the centre and a pump-rod in each corner. Eight 300 horse-power water-tube boilers supply these engines, and their high efficiency can be judged from the fact that during a three-months' test the cost of the coal consumed in pumping each one million gallons to an elevation of one foot was only five and one-half mills!

The largest water supply for any city on the Western continent is that for New York, known as the Croton water supply, because it

KNOWLES
CENTRAL BUREAU OF ENGINEERS

originally drew its water from the Croton River. This water-shed has an area of 362 square miles, and, the annual rainfall being forty-six inches, the yearly water supply is about one hundred and thirty-five billion gallons. The old Croton reservoir had a capacity of only one billion gallons; the storage basins built since and the new Croton Dam, now (1904) approaching completion, will give a total storage capacity of about 75,000,000,000 gallons, or enough to retain the rainfall for a period of seven months. The new dam is largely excavated, being carried down 130 feet below the original bed of the river. As the lower courses of the dam are set into the rock foundations, and as it rises 160 feet above the old river bed, its total height is 300 feet at the deepest portion. The length of the crest is 1050 feet, and the spillway is 1000 feet long. This is one of the greatest dams in the world.

Large dams are commonly built with walls or sides of masonry, and a centre or core also of masonry, the filling being of earth. The masonry is depended upon to keep the water out, and the weight of the earth furnishes the resistance to the pressure of the water. Steel and concrete have been introduced in some dams recently with promising results.

In proportion to the number of people served the most costly water-works in the world has just been finished at the gold fields in the Kalgoorlie district, Australia. Away back in the mountains, 328 miles away, are gathered the clear, sweet waters, and conducted across deserts and salt lakes, over hills, and through deep valleys, it at last finds its way to the thirsty gold fields, where the only water the earth yields is salt and poisonous. Heretofore the people have had to depend on what water could be caught during occasional showers, but there was always the impending danger of a water famine, and it was ever used very sparingly. The pipe line now laid is thirty inches in diameter, and will afford an ample supply for the 50,000 people in the mines. A remarkable problem in the work was to raise the water 2700 feet during its journey. This is accomplished by eight pumping-stations which alone cost $1,500,000. In the mountains great reservoirs have been built seven miles long.

SOME INTERESTING ENGINEERING ENTERPRISES

AMONG the most difficult problems which at times confront the modern engineer are those pertaining to the construction of works designed for maintaining, controlling, or damming large bodies of water. The well-known Mississippi jetties have involved an expenditure of millions in the work of keeping a clear channel among the shifting sands at the mouth of the "father of waters." The work of dredging and ditching at Panama is likely to cost considerably more than a hundred million dollars and to require twelve or fifteen years' time. But we will not dwell on these, because so much has already been written about the jetties, and because it is too soon to write intelligently about conditions at Panama.

Turning to the Old World, we find that there is being undertaken in Holland a work second only in magnitude to that of Panama. More than eight hundred years ago the tempestuous North Sea invaded Holland, sweeping away and dissolving the sand islands north of Amsterdam and flooding the low lands. There were several floods during the period of two hundred and forty years following 1170, the date of the first disastrous inundation, and the total result was the formation of the Zuyder Zee. Land is valuable in Holland, because the country is small and thickly populated, and the shallow Zuyder Zee is known to cover a great many square miles of alluvial land, which if recovered would yield large crops to the farmers, owing to the rich mud deposited there during the centuries of immersion.

The method which has been decided upon for recovering this land is to build an enormous dyke across the mouth or outer entrance that separates the Zuyder Zee from the waters of old ocean. This dyke is a tremendous undertaking, as its total length is twenty-five miles, and it must be built with such absolute and known strength and solidity that there will not be the slightest danger that the most serious gale blowing in from the North Sea can make a breach that will endanger the lives of those who settle on the reclaimed land that it protects. Strange as it may seem to some, sand is the principal material of which this dyke is to be composed. Great mats of interwoven twigs are to be made and towed to the line of the dyke, and there sunk and loaded with enough stones to keep the mat in position while the sand is being poured on. Engineers

have learned that an accumulation of a great many of these mats gives a hold to the sand, which tends to accumulate at such an obstruction rather than to be washed away from it.

Piles will be driven at points where they are deemed necessary to strengthen the structure, and when it is formed it is to be faced on the open side with stones so that the water will not tend to wear it away. The dyke will rise sixteen feet above high-water mark, and will support a railway and driveways along its top. At the mean water level it will be 190 feet wide. Several sluice-ways will be placed in the dyke for the passage of vessels by means of locks to an interior lake, which is to be left at a level several yards below that of the ocean.

The plan is to reclaim or "impolder" (as the Dutch say) only about two-thirds of the Zuyder Zee, the rest remaining as a fresh-water lake fed by the river Yssel. The "polders," or sections of new land, will be protected by dykes, that will be built every few years, so as to take in more land as it is wanted. When a polder is dyked it has to be pumped out, a work that involves a large expenditure of both time and money. The cost of the great dyke shutting out the sea will be something over $11,000,000, and the works contingent upon this, as the building of a canal, some locks especially designed for the navy, a subsidy to fishermen, etc., will swell the total cost of shutting out the sea to $23,000,000.

A total of two hundred miles more of dykes require to be built to enclose the several sections of land that are to be reclaimed. These are to be built in successive periods, one being completed every six or eight years, the intention being not to complete the whole work before 1936. The first polder, which is the smallest, will recover 53,600 acres of land, and will cost about $5,000,000. The pumping out of the water after the dykes are built is one of the most stupendous undertakings known in the history of hydraulic engineering. After the pumping once begins, about seventy million tons a year of water will require to be pumped out until the work is completed. The cost of the dykes for the polders, with the expenditure for pumping out the water, will involve a total of $53,000,000, or $76,000,000 as the whole sum spent on the recovery of the land. When the land has all been regained, it is estimated that the expense to the government per acre of land obtained will be $211. This land will be leased to small farmers and others at $9.50 an acre, which will pay four and a half per cent. on the investment.

Egypt is undergoing something of a transformation, owing

Great Nile Dam at Assiut.

to the enormous dams now building on the Nile for the purpose of impounding or reserving the water during the season of floods and using it to irrigate and render fertile some 2500 square miles of land. Two dams are now completed, one at Assouan and the other at Assiut. The Assouan dam is more than a mile in width, and the central portion is provided with large sluices built of steel and backed with masonry. There are 180 of these, each about eight feet wide, which are sufficient to allow the surplus water to pass.

Courtesy Electrical World and Engineer.

Dam at Spier Falls.

At high water about 900 tons of water will pass through these sluices every minute.

It is an interesting historical fact that the stone for this dam was taken from the same quarry that supplied the temple of Philæ and Cleopatra's Needle, and that when the engineers began taking out the granite blocks they found the marks of the wedges used by the Egyptians thirty centuries ago in splitting the stone.

The dam at Assiut looks like a row of small round towers. Why this peculiar construction was adopted the writer has been

unable to ascertain, but the artistic appearance of the dam is much enhanced by the semicircular fronts of the piers. Other dams are to be added, and when the work is completed the final cost will be not less than $25,000,000. Native laborers are employed to the number of 25,000, working in day and night shifts, for about a dollar a week each, in addition to their board.

A noteworthy dam that is approaching completion in 1904 is located at Spier Falls, on the upper part of the Hudson River. This dam is a third of a mile across the top, and measures 156 feet from bed-rock to crest, having a base width of 115 feet. It supplies water to a power-house of 50,000 horse-power capacity, this being equal to the original installation of the famous Niagara Falls power plant. The water is carried by ten steel tubes, each twelve feet in diameter, to a series of turbines directly connected to generators, each having

A Sea-Going Dredge.

5000 horse-power capacity. The head, or fall of water available for driving the turbines, is ninety feet. It is a little remarkable that the cost of this great plant is only about $2,000,000. The power will be sold to towns and cities within a radius of fifty miles, as Glens Falls, Saratoga, Albany, Troy, Schenectady, and Watervliet.

In the construction of engineering works, such as those we have been describing, dredges and steam-shovels take an important part. Dredges are of several types. What is known as the ladder-dredge has an endless chain of buckets, the lower end of which is dragged or supported on a river bottom, from which the moving buckets scoop up the mud, bringing it to the surface and dumping it in the scows. Such dredges are mounted on floats or steamboats, and some of them are equipped for making ocean voyages. At this date Europe is in advance of America in the construction of

The Lidgerwood Rapid Unloader.

large dredges of this sort, though perhaps the development of machinery for the Panama canal will enable us to catch up with them in the manufacture. The speed and economy with which these great machines can operate under good conditions are instanced by some dredging done at Montreal a few years ago, when about one million yards of blue clay were removed from the harbor bottom at a cost of less than three cents a yard.

The dipper-dredge is the type commonly used on the great fresh-water lakes in America. The Bucyrus Company build a double-dipper machine which makes two dips a minute in twenty feet of water, so that when operating at full speed it may remove 720 yards of mud in an hour. This system is favored in the search for gold-bearing sands in river bottoms. The hydraulic or suction dredge is simply a tube whose lower end is placed in the mud or sand of a river bottom, when a strong suction or pumping draws up the mud and sand from the river bottom. The clamshell or grapple type of dredge, of which the Hayward "orange-peel" bucket is an example, is operated very much like a steam-shovel, except that it grips around and encloses its load instead of scooping it up.

America leads the world in the use and manufacture of steam-shovels, such as are mounted on railway cars for digging out embankments, or mounted on special track for digging canals, trenches, etc. The American type of shovel for railway use differs from the English in that its framework is a railway car, complete with a powerful engine, tackle, etc., while the British shovel is built separately, to be rolled on a flat-car, and sometimes to be operated by a separate engine. An average American railway steam-shovel weighs about 150,000 pounds, and carries a dipper of four yards' capacity. When it is used to load earth on flat-cars for filling-in embankments, the usual plan is to run in a train of perhaps twenty or twenty-five cars, loading each one as it comes up with the shovel, each car taking about six shovelfuls. If the earth or gravel is in good condition, and it does not have to be carried more than a few miles, such an outfit will handle 3000 to 4000 cubic yards of earth in a day at a cost of six cents per yard. If flat-cars are used, they may be unloaded with the rapid unloader or travelling plow, made by Lidgerwood, as shown in the illustration, or if Goodwin steel cars are employed for carrying the earth, it can be dumped automatically while the train is in motion, the speed of the train determining the amount that is dropped at a given point. When the earth has been filled in at the sides of a track it may be shaped or smoothed by a grading-machine, as that shown in the illustration.

Shaping the Sides of a Track with Lidgerwood Grading-Machine.

THE ART PRESERVATIVE OF ALL OTHER ARTS

THE novel of the first half of the nineteenth century often depicted as a hero the poor and talented artist or painter. He was always poor, because there were so few people to buy his pictures.

Courtesy Scientific American.

The Press of Gutenberg.

To-day the profession of the artist is one of the most remunerative, because advance in the art of printing has made it possible to reproduce the artist's work at small expense, so that thousands of copies may be circulated, and every buyer of a magazine or illustrated newspaper becomes a patron of art, contributing his mite to the support of the artist.

The men who helped to bring about this great change have been ranked rather as artisans than artists, though artists in the highest sense very many of them have been—artists in the sense that they practised their art, engraving or printing, with an artistic sense, putting their brains in with their mechanical work to secure the best results. If he who paints a great picture be entitled to encomiums, is not equal praise due the man who makes thousands of accurate copies of the great picture, that it may please the eyes of millions?

Printing has been called the art preservative of all other arts, because without it we should be unable to impart to new generations

Courtesy Scientific American.

Photo-Engraver's Photographic Apparatus.

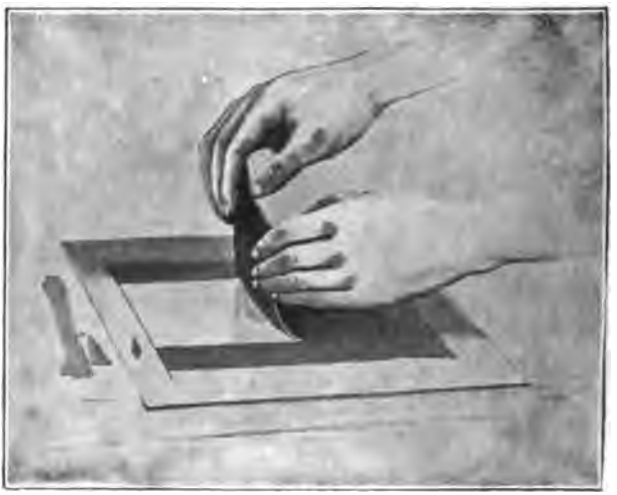
the growth in knowledge of preceding generations. Of all the arts, none has made more progress in a generation than the printing art. I use printing here in the broad sense of reproduction of pictures or print by any process, for the methods are numerous, and many new words have been coined to name these sub-processes, if I may so name them.

Photo-engraving stands pre-eminent as the centre of development of modern printing. Around its introduction cluster a majority of the salient features that make the art of printing what it is to-day. Photo-engraving brought the camera to the aid of the printing-press, enabling the two to work in unison, and let the

world see what is seen by the millions of photographic lenses constantly at work.

Let us read a little printing history, that the methods of modern printing may be more clearly understood. Photo-engraving was a name originally applied to the art now known as photo-etching. This consisted essentially in making a pen-and-ink drawing, photographing this on a zinc plate, and then etching the plate so that the light parts were eaten away, and the lines equivalent to the drawing allowed to stand up in relief, thus giving a plate that could be printed from on an ordinary printing-press, with a form of type.

This was a marked advance on wood-engraving, because it was cheaper, could be done more quickly, and permitted a higher grade



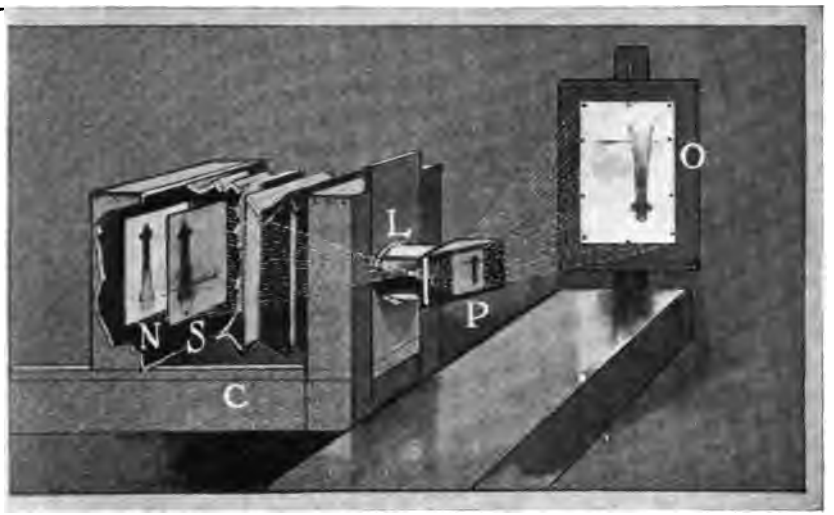
Stripping the Plate.

of illustration. The pen drawing could be made several times larger than the final print, the photograph securing the reduction, and this made it possible to do finer work, with closer lines and minuter accuracy, than was possible with the wood engraver, be he ever so expert.

The next advance in photo-engraving was the gelatin process. This did away with the need of a pen drawing, reproducing directly from a photograph. The method involves briefly photographing on a gelatin film, those portions of the film exposed to the light becoming insoluble in water, whereas the portions on which the photographic shades fall are soluble. As a result, the gelatin film may be immersed in water and all the dots become raised. When

the film dries, they remain raised, and a plate or cast may be reproduced from this film, in which the dots of the photograph are in relief, and can be printed from. Thus is secured what is for all practical purposes a photographic plate suited to the printing-press for the cheap reproduction of photographs.

From a number of photo-engraving processes practised between 1870 and 1890, the half-tone process proved the most acceptable, and is in common use to-day. To secure perfection of results, constant care and the practice of numerous sub-processes are requisite. The most desirable copy to work from is either a good photograph



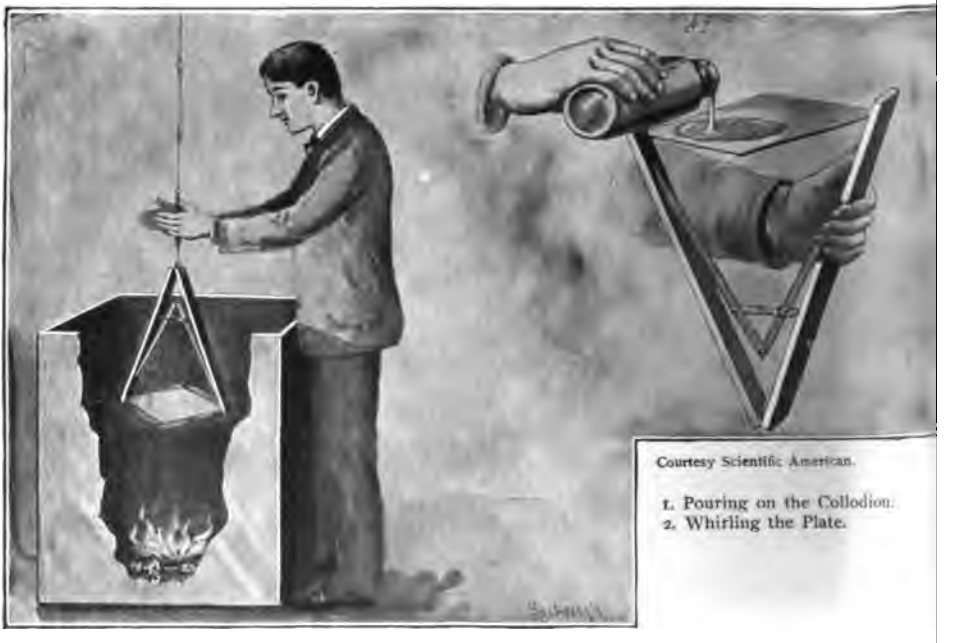
Photographing with Prismatic Reflector.

O, original drawing; P, prismatic reflector; L, lens; S, half-tone screen; N, negative plate. In actual work the negative and screen are closer together.

or a wash-drawing made larger than the final plate is to be. If it is a photograph, and a fine result is wanted, it is usually retouched by an artist who understands what is necessary to secure the best results by this process. The photographic copy is then fastened on a copy-board set up vertically or at right angles to the camera bed, in a position to secure the desired size of plate. The position of the lined screen and glass plate with reference to the lens and photographic copy are shown in the illustration of a prismatic reflector. The reflector twists the image, preventing the distortion that comes when the negative is "floated" off.

The ruled screen, or half-tone screen, as it is more often called, is made of two plates of glass, each of which has been ruled on one

side and cemented with the ruled faces together, the rulings being arranged to cross at an angle. This screen causes the shadow of the picture, known as the image, to appear on the collodion sensitized plate in a series of minute dots, because the light has been broken by the crossed lines of the screen. The shape of these dots varies considerably, and in the light parts of the picture they appear very small, while in the dark parts they approach each other to the point of contact. To produce a fine picture, to be printed on very smooth-surfaced paper, the screen may have lines as close as 250 to the



Courtesy Scientific American.

1. Pouring on the Collodion.
2. Whirling the Plate.

inch, but for average magazine work 150 to 175 lines per inch are employed, while for newspapers, printed rapidly on coarse paper, rulings from 75 to 100 to the inch are sufficient.

A 100-line screen gives 10,000 dots to the square inch, and when the finished plate or the print is examined under a magnifying-glass, it will be seen that while the picture greatly resembles an ordinary photograph, that its dark and light places are made simply by the variation in the size or blackness of the dots. The distance between the dots, measured from centre to centre, is uniform, but the amount of white space between them is greatest in the light parts of the picture, while the dots run together in the solid blacks. After the glass-plate negative is exposed for photographing, it receives

treatment in the dark-room much like that of any other negative. After the negative has dried it is covered with a rubber solution, and this is followed by a coat of collodion for securing greater body to permit of the negative being handled with less danger of injury.

The polishing of the copper plate is done with willow charcoal and water until the highest possible finish is secured. It is next sensitized with collodion in a whirler, which is a device for rotating it rapidly in a horizontal position, with the result that a little collodion poured on the plate is evenly distributed over its surface by

Courtesy Scientific American.

Taking a Proof.

centrifugal force. The copper plate is then printed on photographically from the glass-plate negative in a somewhat modified photographer's printing-frame. Either sunlight or electric light may be used, sunlight doing the quicker work. After printing, the image is developed by placing it under running water. This image is burnt in over a gas stove, when the plate is ready for the etching bath. It is immersed in chloride of iron, and the parts that are to appear white in the print are eaten away, leaving the dots that are to print higher, so that these alone will receive ink on the printing-press.

A press proof is then taken, after which the plate goes to the

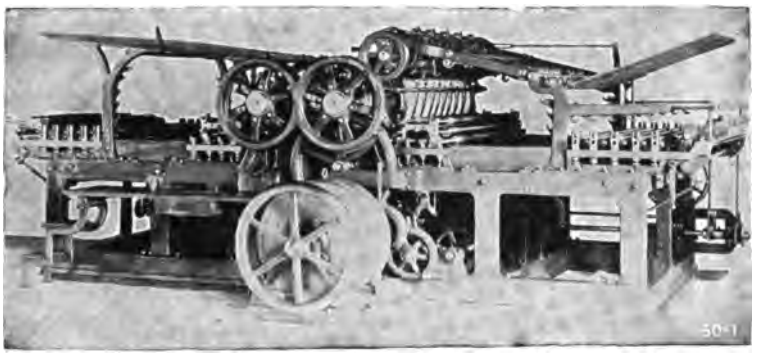
router, who cuts out any parts that are not to show in the print, as the edges, when it is desired to produce a vignette effect. If a black line is to be run around the picture as a border, this is done by passing it to the bevelling-machine, which makes the line with a bevelled cutter.

At this point the work ceases on a cheap half-tone plate, but on the best ones the "finishing" is often the most expensive part of the labor. The finisher paints out with asphaltum varnish those parts of the picture which his artistic judgment suggests had better remain as black as they are, and leaves unpainted the parts that are to be re-etched, to make them lighter. He also examines the plate for minor imperfections and corrects them. The extreme high lights he cuts out with a graver, or often takes out every second row of dots. After the re-etching, if any of the shadows are not of a sufficiently solid black, they are made so by burnishing. When the plate is pronounced perfect, it is usually nailed on a wooden block of the proper size, so that the plate and block together will be just the height of type. The photo-engraving is then complete, and may be printed from in a form with type or may be incorporated with a type page and electrotyped to form a page of a magazine or the like.

The half-tone process has not only cheapened illustrations, but has resulted in making them vastly better and more artistic in quality. The newspaper pictures of 1904 are better than were the magazine pictures of 1865, and the magazine pictures of to-day are better than were the so-called art productions of a dozen years ago, while the once famous steel engraving is being relegated to garrets and waste-baskets before the now common and every way more beautiful half-tone copper plate. The character of magazines and weekly periodicals has entirely changed through the introduction of high-grade illustrations at moderate cost. These are now picture-books, and the publications that have not taken to using them liberally are few indeed. To photo-engraving we also owe the beautiful three-color printing process, which we shall discuss farther on.

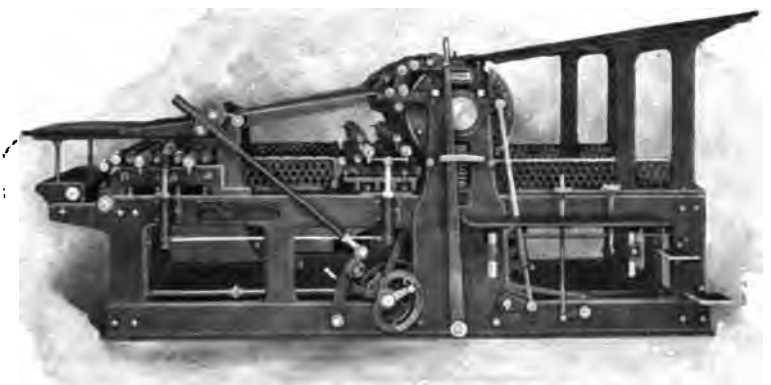
The half-tone illustration has had a marked effect upon the development of printing-presses and upon paper making. To print them clearly requires a smooth-surfaced paper, and one of the first things that the printer learned when he began to use half-tones was that his paper was too rough and irregular in surface to receive a perfect impression from all the minute dots of the plate, the correct printing of which is essential to the making of a good picture. The

paper-maker supplied this want by introducing a paper coated with a mixture consisting essentially of clay and glue, that filled the interstices of the surface, making it smooth and glossy. This coated



The Cottrell Cylinder Press.

paper receives half-tone impressions admirably, but unfortunately it cracks with handling or doubling, so that its durability is seriously reduced. The demand for a non-cracking paper that is also less costly than coated, is met by calendering the ordinary book paper—



The Campbell Company's New Century Press.

that is, compressing it between hot steel cylinders to the last degree of hardness. This gives a paper that reproduces half-tones easily, and is in very common use.

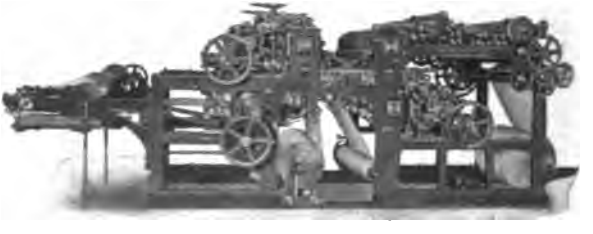
The half-tone plate has a greater printing surface than a wood

cut or line drawing, and, as there are frequently a great number of half-tones in a single form for printing, their use entails greater impressional power in the printing-press. As soon as half-tones became common there was a demand for stronger and heavier printing-presses to reproduce them to the best advantage. The inking devices required remodelling and the impressional power or squeeze had to be doubled and quadrupled. This change has gone

The Scott Cylinder Press.

on gradually, until the cylinder press, on which the great bulk of pictorial printing is done, has been metamorphosed.

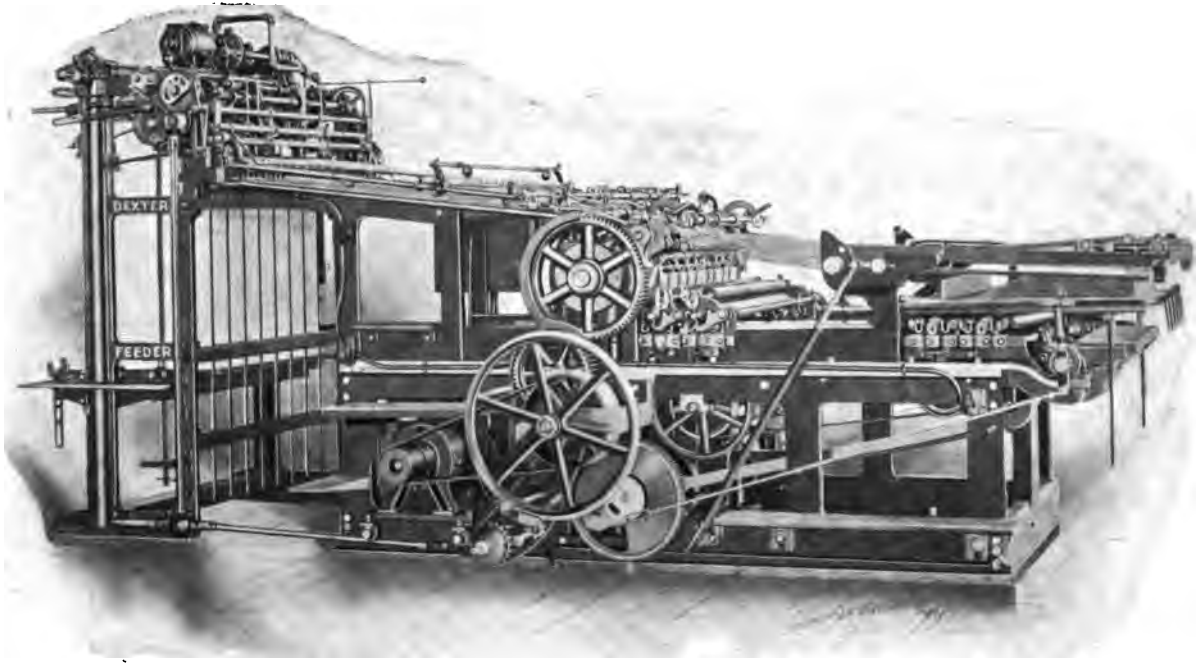
Printing-machines are still called presses by American printers, and the men who operate them are pressmen, although the original type of machine, which really was a press—meaning the Washington hand-press—has been long discarded except for taking proofs. The modern press is really a cylinder machine, in England called



The Scott "All-Size" Rotary Press

by printers "the machine," and is more properly though less commonly called a cylinder, after the most important part. The typical printing-machine now is the two-revolution bed and cylinder machine. Among the best known makes are the Miehle, Century, Scott, Cottrell, Optimus, and Whitlock machines.

The leading presses for printing magazines of large circulation have been provided by the Cottrells, who have built a line of success-



Dexter Automatic Feeder Supplying Sheets to a Printing-Press.

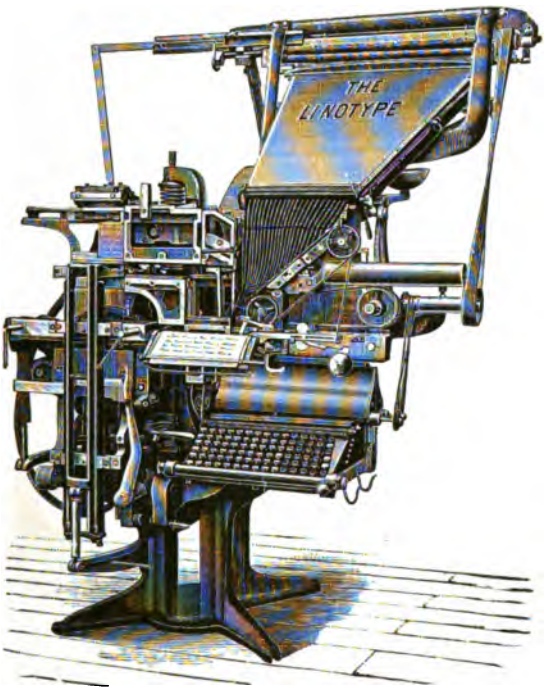
ful perfecting presses, printing the second side of the paper immediately after the first, at the same passage through the machine. For newspapers of medium circulation the Scott web machines and Campbell model webs, and Cox duplex presses are commonly used. Small printing is still done on machines of the style introduced by George P. Gordon fifty years ago, though higher grades of work are done on the Golding, Universal, and Colt's Armory machines.

In printing of the best grade, as from fine half-tone blocks, a great deal of time is spent by the pressman in what is termed "making ready." This work consists in first levelling his form by reducing any blocks that may be too high, and in bringing up to the general level all the parts that are slightly low. This is done by underlaying, that is pasting bits of paper under the blocks wherever they show the least weakness of impression, which to the trained eye of the pressman conveys the information that they are too low. When the form is brought to a true surface, what is known as a flat impression is secured. This prints the type and illustrations as they really are, and for type printing is all that is desired, but for illustrations the pressman must do better to secure artistic results. He must bring more pressure to bear on the dark parts of his pictures, and less on the light parts. By the judicious and painstaking application of overlays and underlays of very thin paper, he produces fine effects at the expenditure of a great deal of time. A form of sixteen pages, well filled with illustrations, often requires ten hours of make-ready, and in the case of the very highest grade of work three or four times as many hours may be consumed before the effects are considered as perfect as can be had, and the machine is allowed to proceed with the actual work of printing. This time is reduced somewhat by the use of patent blankets, containing wire, rubber, etc., to give them springiness.

The most important advance in printing machinery since 1890 has been the development and success of composing-machines, for doing the work of the typesetter or compositor. By far the most successful of these machines is the linotype, invented by Ottmar Mergenthaler, which does not set type at all, but forms lines in solid slugs. An operator at a keyboard somewhat like that of a typewriter fingers the keys for a line, and a series of matrices are assembled. These matrices are flat pieces of brass, about an inch in the longest dimension, and bear on one face the reversed and indented form of a type-face. When a line of these matrices is brought together in the linotype, the operator pulls a lever and goes on fingering his keyboard, while the machine automatically conveys

the matrices to the face of a mould, clamps them tightly over it, makes a cast in a metal alloy resembling Babbitt metal, and delivers its "line-o'-type" on a galley ready to be put in a form and printed from. After casting, the matrices are carried automatically to the top of the machine, finding the proper channels in the magazine by means of different arrangements of nicks in the head of each matrix.

At first the linotype was confined to the use of ninety characters, there being that many channels in the magazine; but by an



The Linotype.

arrangement for handling two-letter matrices in the machine, its capacity was doubled, and it became practical to set italics and small capitals on the machine, and also the minor headings, as for a newspaper. The latest improvement, introduced in 1903, is a double-magazine machine, which is supplied with two-letter matrices, giving a capacity of 360 characters in one machine, and enabling the composition of from four to six faces of type from the one keyboard.

The Simplex type-setting machine, which is the name given the improved Thorne, is the only machine for setting the same type that the compositor sets that ever came largely into use. Its only

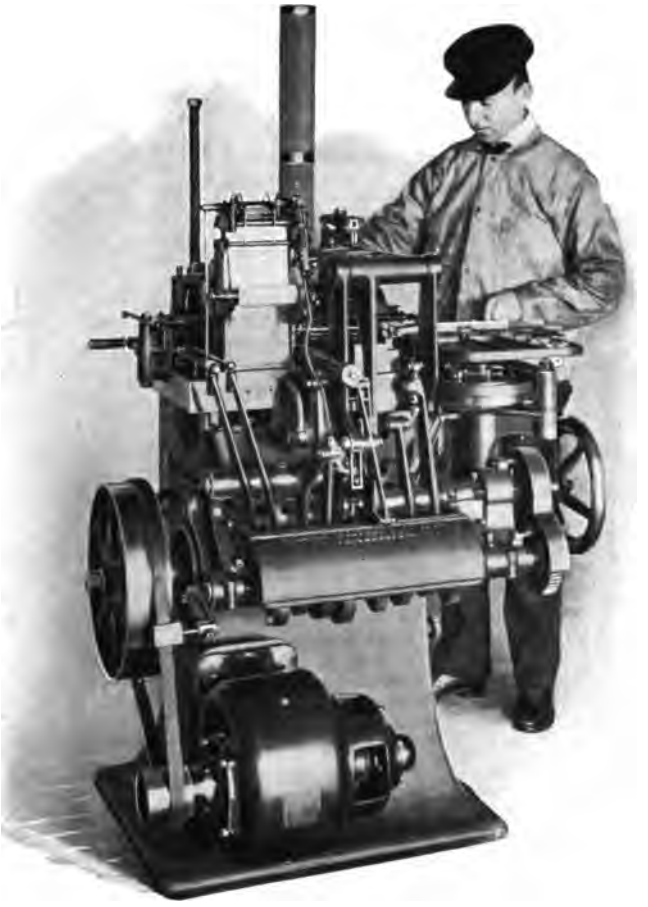
drawback has been the wage cost. As the Thorne, it required two men and a boy for its operation, and as the Simplex, either two persons or a reduced output with one person. The types are placed in the grooves of an upright cylinder, and thrown into a raceway by fingering the keyboard. Though the distribution is automatic, yet the justification, or even spacing of the lines, is done by hand, and

Lanston Monotype Keyboard.

it is this which increases the wage cost. Nevertheless, the simplicity of the machine and its low cost have given it a large sale. A justifying mechanism is shortly to be added to the machine.

The Lanston monotype machine casts and sets type, remelting it at every operation, to avoid distribution. A keyboard with a punching attachment is used to perforate a paper tape, the combinations of holes in which represent letters and characters. This tape is taken to the casting- and setting-machine, which is largely

automatic. The paper is fed backward into the caster, that is, the last word of the article is the first set. Suppose, for instance, that the last word was "end." The combination of holes in the tape allows certain blasts of air to pass down through little tubes, and these set in position parts of the machine so that the mould is ad-



Lanston Monotype Type-Casting Machine.

justed to the proper width for casting a period, while the matrix for a period is clamped over the mould. The period being cast and pushed out into the line, the tape is advanced a step, and presents the holes representing the letter "d," and this is cast in like manner; then the "n" and the "e," next a space, and then the preceding word. The whole operation takes place very much faster than it can be described, 150 characters a minute being a fair speed for the caster.

The Lanston system of securing justification, by varying the widths of the spaces between the words, is unique and original in the extreme. When the keyboard operator has composed as many words as he can conveniently get within a line's measure, he consults a dial that indicates the pressing of certain figure-keys. The calculating mechanism back of the dial has measured the vacant space in the line, and determined the necessary width or thickness of spaces to fill it properly. It shows the result in figures, and when the operator punches the appropriate figure-keys, he punches the tape with holes for the information of the casting-machine. As the tape moves backward through the caster, the holes made by pressing the figure-keys reach the mechanism before the line itself is cast, and cause the machine to set certain parts in position to make spaces of just the required thickness to bring the line to the desired length. In this way all lines are of uniform length. The perfecting of this remarkable machine has cost an immense amount of money, and, although first exhibited in 1892, it was ten years before it was perfected sufficiently to secure a fair sale.

The monoline and typograph machines, which infringed the United States patents of Mergenthaler, have had some sale in Canada and abroad, though excluded from the United States. Each casts a solid line slug, and each has certain merits, but they have not been developed as has the linotype, and have never reached the same state of perfection. It is only fair to add, however, that the monoline machine is far the simplest of the "slug" class, and that it is likely to come on the United States market at an early date.

There are numerous projected machines for doing composition, most of which will never find a market because they are not so good as those in use, but there are two coming machines that seem worthy of description here. These are the Dow typesetting-machine and the Wicks typecasting-machine. The Dow is the only machine using founders' type that permits of the use of all the standard sizes of body type in the one machine; in other words, it is an all-size machine. It is also the only single-type machine that gives a full product with the labor of only one operator. This puts it in the same class with the linotype, as the cost of production should be about the same. It has been held off the market for several years, until its makers were thoroughly satisfied with its smooth operation, and at this writing it is stated that it is to be ready for sale the present year. The machine has an advantage over many other single-type machines in that it will handle type wet or dry, clean or dirty. The setting-machine will do the work of six hand compositors, and

the distributing-machine, which is automatic, will supply three setting-machines with type.

The Wicks typecasting-machine is remarkable in that its speed of operation far exceeds that of any other typecaster. Its normal running speed is 60,000 type per hour, and it actually makes type of a hardness never before attained by any rapid casting-machine. As a drawback, the machine is very costly to construct and expensive to keep in order, and has not as yet found a general market, though considerable type has been made with it, both in London and New York.

But whatever machines may or may not take the market of composition in the future, one thing is certain, that the days of hand typesetting are over, and that every printing-office of the future will be considered incomplete without a composing-machine. The change is owing largely to the inventive genius of Ottmar Mergenthaler, the little German mechanic with a large brain, who spent a score of years in poverty in Baltimore developing the linotype. Eventually he found men of money and business ability to back his ideas, and the line was substituted for the single type as a practical unit of composition. Others divide the honors with Mergenthaler, just as Gutenberg divides the honors of his invention with Fust and Schöffer, and as Hoe has shared the honor of developing the printing-press with other builders; but these three—Gutenberg, Hoe, and Mergenthaler—are surely a great trio, who stand head and shoulders above all others as inventive giants who advanced the art of printing.

Color-work has made great progress within the past twenty years, both in lithographic and letter-press printing. Lithography is the method practised by the makers of chromos that flooded the United States about 1870 to 1875. The name became cheapened and the workmanship of the pictures improved, so the "chromo" was no longer offered to the public. In its place came beautiful birthday, Easter, and Christmas cards, and floral pictures appropriate (or inappropriate) to any and all sorts of occasions. When this fad ran out, the growth of advertising had caused a demand for high-class labels, illustrated signs, and commercial matter of various sorts, and these were supplied by the lithographer in ever-improved quality. The means employed were the gradual improving of minor details of workmanship, together with some mechanical improvements. Chief among the latter was the introduction of the aluminum plate, as a substitute for the lithographic stone. This plate is a sheet of aluminum made porous and attached

to the bed or cylinder of a lithographic press. Being very much lighter and able to hold its design much longer, it has taken the place of the stone to a considerable extent. The American Lithographic Company, of New York, a consolidation of a number of large lithographers, has developed and is developing a line of improved machinery for their own use, which secures artistic effects at reduced cost. The United States Printing Company, manufacturers of colored labels and the like, with establishments in several cities in the country, has also introduced improved methods into its work, which are not offered for sale to the general public.

The letter-press printer has become a competitor of the lithographer in the color field by the perfecting of the three-color process, which was demonstrated to be a success in 1895. This process consists in printing from half-tone plates in the three primary colors—red, blue, and yellow—often with an added keyplate in photo-brown. By this means a picture in all the colors of nature is produced, and the remarkable part of it is that the work is largely mechanical, though requiring great skill and artistic ability to produce. Suppose that the subject to be reproduced is an oil painting. Three photographs are taken of the painting with the negatives exposed exactly in the same position, so as to give pictures of the same exact size. In taking the photograph for the plate that is to be printed in yellow ink, color-screens and other devices are employed to absorb the blue and the red light; in taking the photograph for the red plate, the yellow and blue rays are absorbed, and the photograph for the blue in the same way. The result is three pictures, each taken in yellow, red, and blue light respectively. A half-tone plate is made from each photograph, and three electrotypes made from these are printed one after the other—that is, superimposed—in their proper colors, producing an almost exact duplicate of the original painting. The keyplate in photo-brown is used to help out any weaknesses in the reproduction, and in the best work there are also a great deal of retouching of the plates and much finishing to secure the result. The printing also requires special care, as one color has to be registered exactly on top of the other with an allowable error of only about one three-hundredths of an inch. Three-color pictures when well done present effects as good as lithography in eight or ten colors, and hence the cost of the three-color process is less. This is the usual method employed to produce colored illustrations for the magazines.

Paper-folding machines, for books, magazines, etc., have made rapid advance during recent years. By the introduction of a drop-

BLUE PLATE

COLORS SUPERIMPOSED

See Chapter entitled "T

UNIV. OF MICH.

roll and other devices it became practical to feed the sheets in with the broadside or longest dimension to the gauges, which permitted increased speed. Folders are now built in all conceivable forms for handling sheets of book-forms in all sorts of ways, folding one sheet inside of another, pasting, attaching covers, etc.

The series of Smyth machines have created a revolution in the work of binding books. The book-case machine, as it is technically called, does not make the familiar library bookcases, but is a machine for making book-covers, which were all made by hand until a few years ago. It operates as follows: The boards are put into a magazine at the rear of the machine; the glue is heated and is in a tank underneath the front of the machine, and the back-lining is at the

Smyth New Model Book-Case Machine.

rear of the machine in a roll. The operator stands at the front of the machine and simply feeds the cloth to grippers similar to those on a printing-press, and the machine does all the rest automatically, producing cases more uniform and superior in every way to hand-made cases. The corners are turned in, and, owing to the water-pressure which is used to press the cases instead of rolling them, the original finish of the cloth is preserved and every part of the cloth is securely glued to the board. When it is desired to make cases without back-lining or gluing the backs, devices are brought into play that prevent the glue from going on to the backs of the cases, leaving the backs entirely dry. Bevelled cases can be made as well as ordinary cases. Round corners are made only on a special blank-book machine.

The Smyth book-sewing machines are manufactured in four sizes. The arm that carries the signature into the machine is provided with punches that make holes for the needles to pass through, therefore it is unnecessary for the work to be sawed out or in any way prepared for sewing. The work is sewed continuously, one signature to another, and one book to another. The work, after being sewed, is projected on to a table at the rear of the machine, and the books are separated either by the operator or, where several machines are run, by an assistant, who can take care of a number of machines. The stitches are so made that the act of separating the books locks the stitch, so that each book is complete in itself and

Smyth Book-Sewing Machine, No. 4.

does not rip. The sewing is equivalent to what is known to bookbinders as "all-along" sewing. Each needle uses a separate thread, making its own "kettle" stitch; therefore each stitch is complete in itself, and should all the stitches in a book be cut excepting one, the one stitch is not affected by the cutting of others, and the book would not come apart unless all the stitches were cut.

The Smyth casing-in machine will handle books of any size up to 9 by 12 inches at a speed of from 15 to 18 books per minute. The book to be cased-in is placed upon one of the arms of the machine by an operator. The arm revolves, placing the book in the machine, the case is brought forward from a magazine automatically and positioned on the book; the book is pasted, a heavy line of paste being placed directly where the hinge of the cover

comes, the case is drawn tightly into position, the hinge is made, and the work is completed. The pasting is done with absolute uni-

Smyth Book-Case Machine—Small size.

formity; the minimum amount is placed upon the work, and there never is any sticking of the leaves after the book comes from the machine.

Courtesy E. C. Fuller & Company.

Rotary Board-Cutter.

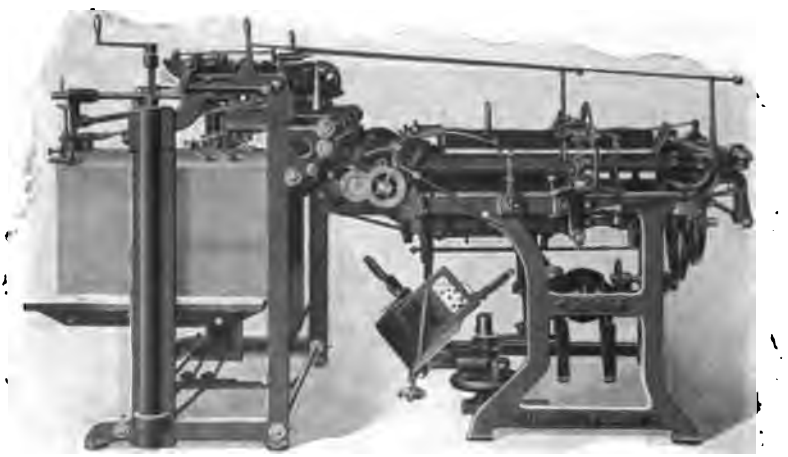
The Smyth gluing-machine is designed to evenly apply hot or cold adhesive material to any kind of fabric, covering either all one side of the fabric or any desired portion of it. It is equipped with

an automatic take-off which lays the glued or pasted fabric, moist side up, on a conveyor that travels away from the feeding operator.

The paper-feeding machine was first introduced for feeding

Smyth Gluing-Machine.

single sheets to ruling-machines, and later to folding-machines. About 1895 it was sufficiently perfected to be attached to cylinder printing-presses. It came rapidly into favor, and now, in 1904, there are three paper-feeding machines on the market, and most



Dexter Feeding and Folding Machines.

periodicals of very large circulation that do not use rotary printing-presses are fed to single cylinder-presses supplied with sheets by these feeders, which thus supplant the hand-feeder.

A sheet of paper is a difficult thing to handle automatically in a machine, because there is so much uncertainty about it, and years of expensive experimenting were gone through by all of the concerns that have placed paper-feeders on the market. In the most common form of paper-feeders the sheets are stacked in a pile of several thousand sheets on a platform. The top sheet of the pile is kept at a level with the feed-board of the press by a mechanism that hoists it little by little as its height is reduced by the feeding off of the sheets. A rubber buckles each of the rear corners of the top sheet, making apertures, into which slight puffs of air are blown. This separates the top sheet so that it can be advanced readily, and it is carried forward by tapes to the guides of the press. If two sheets go down together, a delicate calipering device notes the increased thickness, and sets in operation mechanism for stopping the press. The same thing occurs when a torn or doubled sheet is presented to the guides. The delicate mechanism detects it, and stops all the machinery, while the attendant makes matters right, and starts up the work again.

The rotary board-cutter, for cutting bookbinders' board, has largely superseded the employment of the paper-cutting machine for this class of work.

Thus, briefly, the writer has endeavored to sum up the principal recent advances in the art of printing. They are important to all industries, because printing is essential to the spread of learning, and the better and cheaper the printing, the greater will be its dissemination and the resultant public gain in useful information. The printed page must ever be the storehouse of learning, the means by which the wisdom and experience of one generation are carried on to the next, so that the volume of combined knowledge is ever on the increase, leading us to wonder when man will pause in invention or reach the limit of all knowledge. Like the electric note sent out on a Hertzian wave that may be heard and interpreted by any one within thousands of miles having an instrument properly tuned, so the pages of the book of knowledge are open to all those who can read them. The common school that teaches the boy how to read, the college that teaches the young man how to think, have but prepared the brain for the stores of information rolled off the million of printing-presses that operate in every habitable town on the globe.

THE MAKING OF NEWSPAPERS AND PERIODICALS

THE early newspapers of America were patterned after those printed in England, being of small size and containing mostly essays, letters, and sometimes notes of events happening at a great distance. The idea of news, as we now understand it, seems to have been unknown in the eighteenth century. Only those things that happened at a great distance were considered worthy of record: a burning, a murder, or a riot near at hand was supposed to be known to everybody, therefore not a subject worthy of being put in print. When an editor did occasionally write of anything pertaining to the time and place in which he lived it was usually for the purpose of lampooning or abusing some person or persons obnoxious to him.

A few advertisements were inserted in these early newspapers, these also being of a character very unlike the commercial announcements of to-day. Before 1840 most of the newspapers published came out at weekly intervals, and at that date there were daily papers in only the largest cities of the world, these being small four-page publications of limited circulation.

The Civil War in the United States did more to teach the newspaper editors of the country what news was and what people wanted to read than they had learned in the previous half-century. The stirring events of those times and the demand made by the public for prompt information regarding the movements of the armies, battles and skirmishes, and lists of dead and wounded, created a journalism based on present-day news. When it became apparent that the war was drawing to a close, the query was often made, "What will the newspapers find to print when there are no more battles to record?" But the editors had no trouble in filling up their columns, having learned what it was that the public craved, and since that time in every live newspaper office the difficulty has been to find space enough for all the news matter.

After the war the price of white newspaper was considerably reduced, with the result that the daily newspaper developed rapidly, and by 1875 nearly every small city in the United States had at least one daily paper, while to-day there are few towns of 5000 population that do not support a daily issue, and cities of 25,000 are

usually supplied with two or three morning and two or three evening papers.

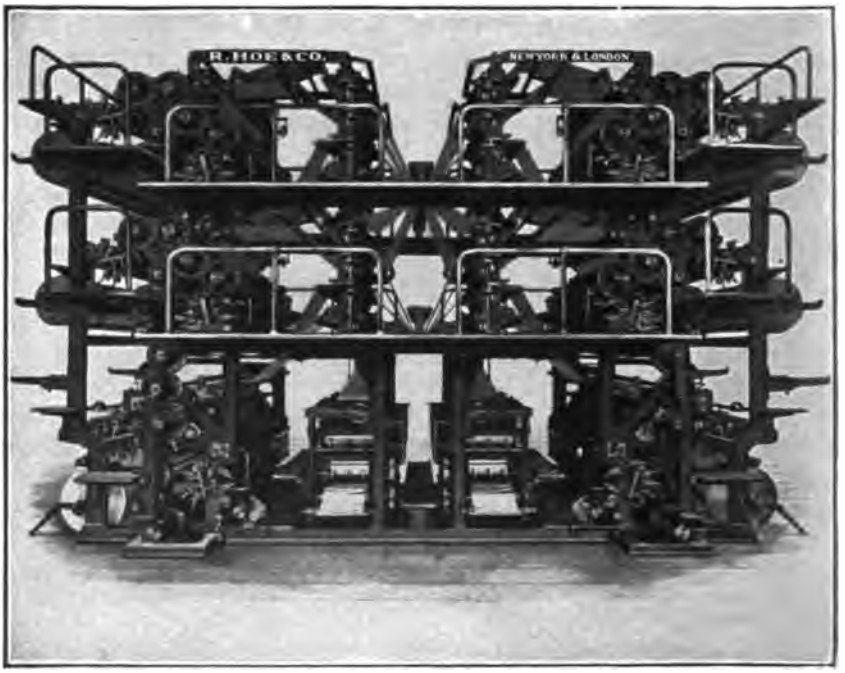
There has come to be a marked line of difference between the daily and weekly newspaper, the monthly periodical, the trade paper, and the magazine, and they require to be described separately. Let us consider the daily newspaper first. In 1800 there were about a dozen daily papers in the United States, these having four pages each, the size of page often not exceeding six by nine inches. They were printed on wooden hand-presses which could not be run faster than about 200 copies an hour with the labor of a man and boy. Under such conditions, large circulation or much influence were out of the question. When the iron hand-presses were introduced, the papers were made a little larger, but were otherwise about the same. About 1840 single cylinder-presses began to come into use, which would print from 500 to 1000 papers per hour, one side at a time.

These cylinder-machines were steadily improved, steam-power being applied to them, so that by 1850 it was common to operate them at a speed of twelve or fifteen hundred an hour. This was a faster speed, however, than the presses were capable of maintaining, and the practice of daily newspaper managers in pushing the machines to the limit of their speed resulted in frequent breakdowns. About this time the firm of R. Hoe & Co. began building the double-cylinder machine, employing two men to feed in sheets simultaneously and doing double work. These machines were capable of turning out 3000 or more papers per hour, printed on one side only. This was followed by the four-cylinder machine, which again doubled the capacity of the press, and next came the eight- and ten-cylinder presses.

Acquaintance with more recent newspaper machinery makes the old eight- and ten-cylinder presses appear as very clumsy makeshifts, yet they were the machines principally relied upon by the growing newspapers of the United States, as well as England, during the period of the Civil War. About 1876 the modern web-press, feeding from a roll of paper and printing from stereotype plates, delivering its sheet printed on both sides and folded, came into general use, after which the daily newspapers were no longer hampered by having to put up with slow or uncertain printing machinery.

The general introduction of the linotype composing-machine about 1890 put the work of type composition on a par with printing facilities, making mechanically possible the enormous daily newspapers of large circulation.

The work of news gathering is a product of evolution much as was the development of the newspaper press. During the Civil War the daily newspapers began to spend money on telegraphic despatches to obtain quick news. This practice grew, and in time there was established in New York what was known as the Associated Press, being a combination of the leading daily newspapers for securing telegraphic reports of important matters all over the world. This service grew and improved, and individual newspapers of special enterprise spent more and more money for news for their



Hoe's Latest Large Color-Printing Newspaper Press.

exclusive use, and various minor news agencies were established for the dissemination of news.

Every large daily newspaper divides its work into departments, one editor having charge of the telegraph news, one of the city news, and often one of the sporting department, book reviews, and other literary features, as well as editors who write editorials, and what are known as copy editors or copy readers, who go through the copy to cut it down and see that it contains no libellous matter or anything contrary to the policy or principles of the publisher. The reporters are the men who make most of the copy, and they

work mainly on assignments under the direction of the department editors. The work of one man may be confined entirely to reporting court news, another to fires and accidents, another to interviewing prominent men, and so on through the various fields of news gathering.

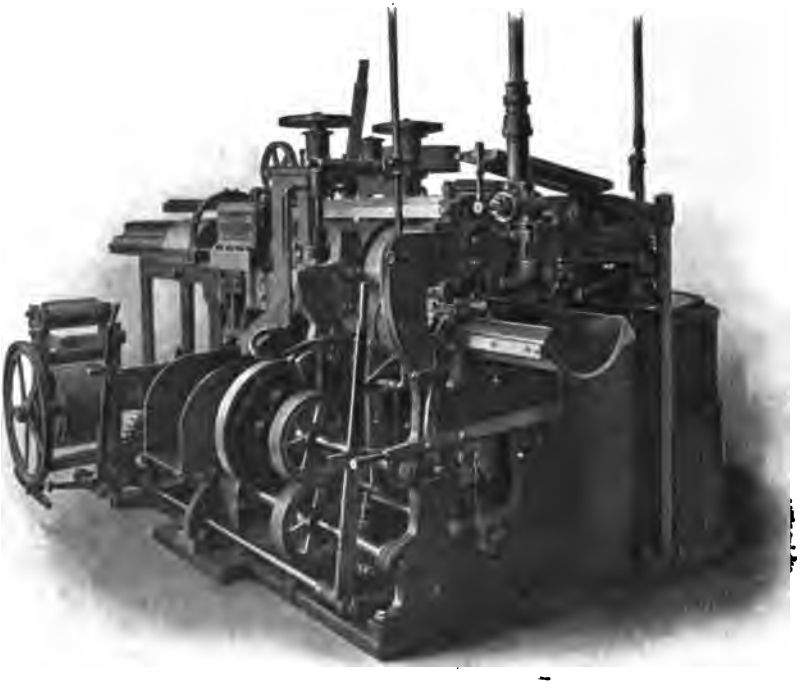
Every great daily newspaper has special correspondents in the larger cities, whose duty it is to write exclusive news stories of the most important events of the locality. Very many reporters in the smaller cities earn more or less money outside of their regular work on the local newspapers by sending occasional telegrams of the more important happenings to the larger newspapers or news agencies of the great cities.

The printing of daily newspapers and periodicals of enormous circulation that do not require the highest grade of printing, is done on Hoe, Scott, and Goss web-presses, that print papers as large as thirty-two pages on a single machine, and at speeds as great as 100,000 an hour for eight-page papers. The most important advance in these machines during the past decade has been the introduction of color-printing devices. It is true that very much of the color work done on these rapid machines for the Sunday papers has been poor, and much of it unqualifiedly bad from an artistic point of view. Still it improves, and one occasionally sees really attractive color pictures in an Easter or Christmas supplement. The largest printing-machine ever constructed is the color press recently delivered by R. Hoe & Co. to the New York *American*, and is one of four such presses especially designed for the Sunday magazine supplement of that paper. Some idea of the size and capacity of these presses may be gathered from the following interesting statistics and comparisons compiled and published by that paper:

"It would take eight locomotives, each travelling at the rate of sixty miles an hour, to unroll paper equal to the combined speed at which papers are printed by the four presses. At their full capacity the four presses could print enough papers in fourteen hours and fifty-three minutes to encircle the earth. There are 50,000 separate pieces in each machine. After each press had been completed at the factory it took one month to take it apart again for shipment to the press-room. To box the four presses for shipment would require 60,000 feet of lumber and 2000 pounds of nails. In the aggregate they represent 160 three-horse truck loads, or sufficient material to fill twenty-eight freight cars. When set up on the solid brick, stone and concrete foundations each press will be thirty-five feet long, seventeen feet high and twelve feet wide. Each press is equivalent in size to four standard railroad locomotives. The four presses have sixty-four ink fountains."

Stereotyping is the process of making a single-plate reproduction of a form for printing in a soft metal alloy of lead with a

little tin, etc. Daily newspapers, printed on rotary presses, take an impression of each page of type in a papier-maché sheet, and insert this in a curved casting box, and so cast a curved stereotype, that is clamped on the cylinder of the press, for rotary printing. Such curved stereotypes were made entirely by hand-operated machines until 1890, when the autoplate machine was installed in the office of the New York *Herald*. This is an entirely automatic machine for making stereotypes at the rate of four a minute from



The Autoplate or Automatic Stereotyping Machine.

the papier-maché matrices fed in by an attendant. It is the invention of H. A. Wise Wood, and is the first radical improvement in stereotyping made since the introduction of the papier-maché process. The machine is now used by the larger newspapers throughout the world, because it saves them about twelve minutes of time between the giving out of the last copy for the paper and its appearance for sale on the streets. For these twelve minutes newspapers have been willing to pay $25,000 each for the machines; such is the enterprise of twentieth century newspaper publishers.

As the linotype revolutionized the work of typesetting and the

rotary web-press the methods of newspaper printing, the autoplate has revolutionized the stereotype-room; and thus for the first time in the history of the daily press the editorial department is linked to the street by a chain of automatic machines that are all of astounding utility and make possible the mechanical work of turning out a million or more newspapers in one establishment within a few hours. The autoplate sets a bridge between the composing-rooms and the press-rooms, and cuts out the last link of time-destroying hand-work from newspaper production.

The autoplate consists of a casting mechanism and a series of finishing mechanisms which automatically co-operate in one machine to do the entire work that was formerly done on four or five hand machines at a single operation. The machine will either make a series of plates from a single paper matrix or will make a different plate every time the operator pulls out one matrix and inserts another, which is done without delay.

When the paper matrix is fed in place, the operator pulls a lever, and a curved chamber, the exact size and shape of the desired plate, closes down on the matrix. Hot metal is forced in for a cast, the casting-chamber being under an elastic pressure, which, as the plate shrinks in cooling, follows up the shrinkage with fresh metal, and thus makes unusually sharp and clear printing plates. Within a few seconds the cast is cool enough to be pushed out to the next stage in the machine, where it is shaved on the inner side, and then passes on to have the ends bevelled and the four edges dressed close to the type matter. The finished plate ready for the press is pushed out at the rear of the machine, not having been touched by human hand until it is ready to take away.

Within the last dozen years illustrations have become a prominent feature of daily journalism, and the artist and "camera fiend" are as important members of a newspaper staff as the reporters and editors. When it is necessary to give pictures of a large fire occurring in the night-time, and the printing plates are required to be on the presses by three o'clock in the morning, it will be understood what a hustling job has the artist, who must rush to the scene and make a few hurried sketches, then return to the office and execute a large pen-and-ink drawing on the double-quick, allowing time for the mechanical work of making the printing plate after the drawing is done. The illustrations produced most quickly are those done by the chalk process, in which the picture is engraved or scratched on a metal plate having a surface of chalk that is removed by the graving tools. As soon as the picture is thus engraved in the chalk,

a stereotype for printing can be made promptly without any intervening process. Of course, half-tone engravings and zinc etchings require more time, although they are produced for newspapers with marvellous celerity.

The advertising of a great daily newspaper requires as much labor and attention as the gathering and printing of news and illustrations. There must be a corps of efficient men to wait upon the larger advertisers and secure and hold their business, seeing to it that their announcements are printed in a satisfactory way. There must be men to give attention to the building-up of "want" advertising, which latter is esteemed of great value, not so much for the price it brings, as for the fact that it also attracts readers to the newspaper.

A daily newspaper of importance requires a circulation manager, whose business it is to see that the paper is pushed into new fields wherever possible and made to hold its own in the sharp competition that exists in the old field. There are many minor departments of work on the daily, as may be better understood when it is remembered that there are several newspapers in the United States that have more than a thousand men on their office pay-rolls.

The daily papers in small cities whose business does not afford a large telegraphic service are in the habit of using what is known as "plate" matter, this being news or miscellaneous matter such as any daily newspaper might print, prepared in advance by companies in the larger cities, put into type, and made in the form of stereotype printing plates of the size of one column each. This plate matter can be purchased by small daily papers at the astonishingly low price of twenty to fifty cents per column, and the quality of the reading thus furnished is as good as that of metropolitan newspapers, the only drawback being that the news service is a few hours later. The use of these plates enables the daily papers in small cities to put on an appearance very similar to the great dailies of the great cities. They prepare and set up their columns of local news and advertisements, printing them with this plate matter on presses adapted to the size of their circulations, thus placing the entire news before their readers every day.

The daily newspapers commonly sell at either one or two cents, though some are furnished at the price of ten cents a week. The one-cent dailies secure the larger circulations, but, as a rule, lose a little money on the sales of their papers, which they have to make up by securing a higher price for the advertising. If it were not for the advertisements, which constitute the largest portion of re-

ceipts of most newspapers, the public would be unable to buy them as cheaply as it does.

The Sunday newspaper is usually a special issue of a daily containing a larger number of pages, and selling at a higher price. When Sunday issues first became common there was considerable objection to them by the clergy and religious persons who regarded them as a desecration of the Day of Rest. Their growth and uni-

Editor Dictating to the Phonograph.

versal sale has come in spite of this opposition, which is now largely silenced, the opinion being prevalent that Sunday newspapers are quite as good as the people who read them, and that they will improve whenever the public demand a higher grade of Sabbath literature.

The weekly newspaper in cities has been largely supplanted or driven out of business by the daily, and, as a rule, continues to exist

only in country towns and small cities where the population is not sufficient to support a really good daily. These country newspapers draw largely upon the manufacturers of "plate" matter, or else they use what is known as the "patent side"—that is, one side of a newspaper printed at very low cost in some large city by a company that makes a business of furnishing such a service. The editor of a country weekly, who is usually also the proprietor, and often his own reporter and foreman, gathers the local news of the town, with what advertisements he can obtain from the merchants, eking out a living by doing job printing. One or two printers and several boys, who are supposed to be learning the printing business, constitute the average force of the country newspaper office.

What is known as the trade paper is largely an outgrowth of the last generation. It is a publication issued usually either weekly or monthly, devoted to the interests of a particular trade or industry, and finds its support mainly from those advertisers who have machinery to sell to the men engaged in that industry. Some of these trade journals have become very profitable properties, and are relied upon as the leading centres of information and exchange of thought in the particular trade to which they cater. At this writing there is not in the United States a single industry of any importance that is not represented by one or more trade journals; while in such large industries, as electrical machinery, the iron trade, printing, railways, and the like, there are often a dozen or more competitors seeking to serve the people interested in that particular business.

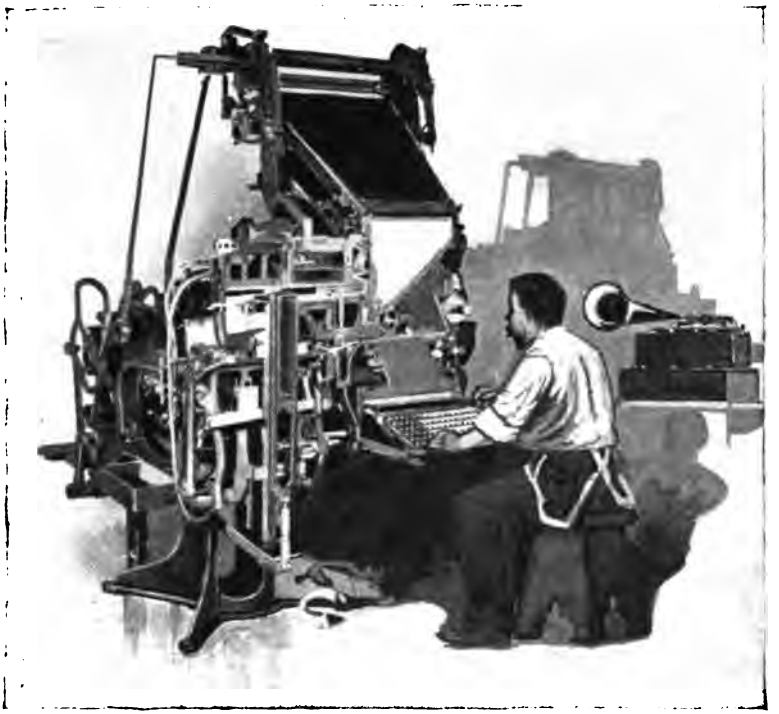
The name of class journal is commonly applied to those publications which cater to persons interested in a special subject, as religion, agriculture, horticulture, hypnotism, or the like. These are neither as numerous nor as successful as the trade journals, although there are a number of special instances of marked success.

Magazines and weekly literary publications of high character are in a class by themselves, and depend largely upon their artistic as well as literary excellence for success. Space forbids enlarging upon the work of these publications, as they are more or less familiarly known to the public.

The newspapers of Europe are, as a rule, behind those of America in enterprise, and the average British newspaper of a given date is usually the equivalent of the American newspaper of five to ten years earlier. There are exceptions, however, and a few newspapers in London and Paris are the equals of the New York dailies in business enterprise, as well as in success in attaining large

circulation and influence. They have not as yet secured the advertising patronage that comes to the American newspaper, as the average British and French merchant is not educated to the point of spending as much money in advertising as his American contemporary.

The newspapers of America consume nearly one billion pounds of white paper annually, according to the United States census, but the amount is believed to be in excess of this figure. There is con-



Composing on the Linotype from Phonograph Dictation.

siderable discrepancy between the census returns as to newspapers and the reports of newspaper directory publishers. The census returns for 1900 report only 18,226 newspapers in the country, whereas the directories gave about 20,000 at that date, and nearly 21,000 at the present writing. Probably the truth is between the two figures, as the plan of the Census Bureau is to omit those newspapers that do not report, whereas the directories retain such on their lists unless they are known to be defunct. Adding magazines, trade papers, and other periodicals to the list of newspapers would

probably give a total of about 25,000 now issued regularly in the United States.

Taking the census figures, which are probably, on an average, ten to twenty per cent. below the actual facts, the 18,000 and odd newspapers of the United States are issued from a little more than 15,000 establishments, and give occupation to 122,000 wage-earners. The capital invested is $192,000,000, and the newspaper products are valued at $176,000,000, of which a little more than half is advertising receipts. The aggregate number of copies of all publications issued in the United States during the census year is given as a little over 8,000,000,000, this figure being nearly double what it was ten years previous.

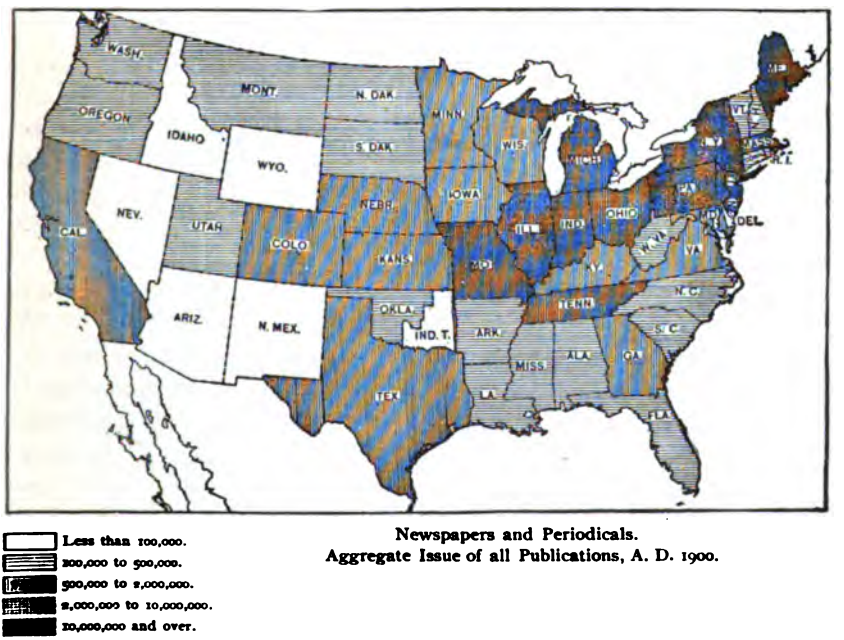
An examination of statistics shows that during the last twenty years there has been very little change in the relative space devoted by the newspapers to news, politics, and general reading, but they do show that those newspapers which confine themselves mainly to the business of publishing news, increased in business at the expense of those devoted to general literature, art, music, fashion, fraternal societies, etc.

There are nearly as many newspapers and periodicals printed in the United States as in all the rest of the world combined. The circulation of daily newspapers in this country shows that there is a little more than one copy of a daily paper printed for each family, while the copies of weekly and monthly publications are sufficient to supply one of each issue to every two inhabitants. The average circulation of daily newspapers in the census year was almost 7000 copies, that of weeklies being a little over 3000, and of monthlies about 22,000 per issue.

New York City takes the lead in newspapers and periodicals of all classes, having no less than fifty-eight daily newspapers, with a combined circulation per issue of nearly 3,000,000; Chicago comes next with thirty-seven daily newspapers, and Philadelphia third with twenty-one. The average number of daily papers in the twenty-seven leading cities of the country is nine per city, of which a little more than half are evening papers. In the smaller cities the evening papers outnumber the morning papers in the ratio of three to one. During recent years the evening newspapers have gained in business in the larger cities, owing apparently to the fact that they are on sale a greater number of hours, some of them appearing as early as nine o'clock in the morning, and most of them by noon, and issuing regular editions up to six o'clock at night, holding a considerable sale up to eight o'clock or later in the evening.

The accompanying map taken from the special bulletin of the

United States Census Bureau issued on the subject of Printing and Publishing, shows graphically the sections of country where newspaper circulations are the largest. It will be noted that the circulations follow very closely the populations. Of 18,000 and odd newspapers and periodicals reported by the Census Bureau, 2226 are daily papers, 12,979 are weeklies, and 1817 are monthlies; 952 are devoted to religion, 307 to agriculture and kindred subjects, 190 to commerce, finance, insurance, and railroads, 520 are classed as trade journals, 239 as devoted to general literature, and 200 to fraternal organizations.



Newspapers and Periodicals.
Aggregate Issue of all Publications, A. D. 1900.

The New York *World's* estimate of the number of newspapers (not including magazines or periodicals) published on the globe at the beginning of 1904 is as follows:

United States and Canada, 21,451; Germany, 7500; Great Britain, 9500; France, 4500; Japan, 2000; Italy, 1500; Austria-Hungary, 1200; Asia, exclusive of Japan, 1000; Spain, 850; Russia, 800; Australia, 800; Greece, 600; Switzerland, 450; Holland, 300; Belgium, 300; all others, 1000. Of these more than half are printed in the English language.

Taken altogether, the newspapers of America lead the world, and deserve a large share of the credit of placing the United States in the front rank of great nations.

THE AGE OF PAPER

THE age of electricity and the age of steel are frequently referred to in the daily newspapers and magazines, but it certainly appears as if the paper industry was quite as much entitled to that sort of distinction. Without paper we should be without printing, and without printing there would have been no development of either electrical machinery or steel construction or of the knowledge that has enabled men to develop these great industries. All paper was hand-made until about 1800, when the Fourdrinier brothers

Making Paper by Hand.

invented the paper-making machine, this being one of the few instances where a machine has reached its full development from the hands of the first inventors and builders. While the paper-making machines of to-day are very much larger and more complete than the first ones built by the Fourdriniers, yet they are the same in essential principles, having the same leading characteristics.

But for the paper-making machine turning out paper in the roll, fast rotary printing-presses would be impractical and the progress of printing would have been much delayed. There is no more common article of manufacture than paper, and there is scarcely a trade or business that is not very much dependent upon its use. Without cheap paper half of the businesses of the country would

be paralyzed. It is because paper is so cheaply produced and so easily obtained that we seldom think of its value in all lines of industry.

In 1794 the first paper-mill of the United States was started in Troy, New York, having a capacity of five to ten reams a day of rag pulp. Several other paper-mills were started during the following years, manufacturing rag pulp by hand until 1817, when the first steam-mill was started at Pittsburg. By 1842 there were some 50,000 persons employed in the paper-mill industry in the country, producing paper annually of the value of $15,000,000.

Logs in the Forest.

Pulp-straw made its appearance in 1857, being manufactured at Fort Edward, New York. By the time the Civil War broke out newspapers were using this straw-paper very largely, the price of rye straw increasing from $6 to $20 a ton. Poor and brittle as this paper was, and hard on printers' type, yet the newspapers were glad to get it at from twelve to twenty-six cents a pound during the war. Newspaper circulations were largely stimulated by the political excitement culminating in 1861, and as a result the product of our paper-mills began to exceed that of Great Britain and France. A boom in paper-making came with the introduction of wood-paper

about 1870–75. At first wood-paper was regarded as a cheap article comparable with straw-paper; but, as its merits were better understood and as the makers learned improved ways of strengthening and finishing, its popularity began to grow, and to-day ninety-nine one-hundredths of the world's paper made is of wood, fine papers designed for the higher grade of artistic printing being manufactured from wood-pulp and depending upon sizing and calendering for their beauty.

A Log Raft containing 6,000,000 Feet.

Cellulose is the chemist's term for the substance obtained by pulping wood, as in the manufacture of paper. Wood-pulp is the common term used in the paper trade, meaning what its form implies—wood that has been reduced to a pulp. Most of the wood used in the manufacture of American papers grows in the forests of Canada and the northern borders of the United States.

The hardy lumbermen chop down the trees and lop off the branches, leaving the trunks to lie until the logging season sets in. The transportation of the logs to market involves great ingenuity

because of their size and weight, and the fact that they are obtained in sections where there are no good roads or ordinary methods of transportation.

Advantage is taken of the natural slopes towards the streams to form chutes down which the logs readily descend during wet or icy weather by force of gravity. Very rude railways are also employed at times or any special device that the locality and ingenuity of the man in charge can suggest. When the logs reach the streams during the cold weather, they must lie there until the ice breaks up, when the lumbermen prepare to go on the "drive." Logs are constantly forming jams in the streams, and when one of

Courtesy Jeffrey Manufacturing Company.

Hauling Chips to the Paper-Mill.

these occurs it becomes the difficult task of the lumbermen to walk over the floating logs and find the log that serves as a key to the jam, cutting it away so as to break the jam. The instant the jam begins to yield is the dangerous one for the lumberman, as he must run over the tops of the logs for shore in a race for his life. If he falls between the logs at such a time, when the pent-up force of the stream is bringing down thousands of heavy logs past the point of stoppage, he is sure to be crushed like an egg-shell, and usually his companions never even discover his remains.

The dangers of logging seem to give it an added charm in the eyes of the lumbermen, who acquire astonishing skill in balancing, and appear as much at home on a stream full of logs as a dancing-master is on a ball-room floor. These hardy men keep their logs

in motion until they reach a large sheet of water, where they can be tied in rafts and floated to the mills. If the logs have been cut in a maritime province of Canada, they have yet a sea-voyage before reaching the paper-mill, or, if in the lake region, a similar trip across the waters of one of the great lakes is required to bring them to their destination. For such voyages the logs are made up in great rafts for towing. The sea or lake voyage is uneventful enough in fine weather, but a storm is liable to break up the raft and scatter the logs for miles, with no little danger to the sailing craft in the vicinity, as a collision with a big log is damaging to the side of any vessel.

Paper mills are invariably located in the vicinity of water, as near some large water-fall as practicable. The water-fall is necessary for procuring cheap motive power, as well as a plentiful supply of water, which is essential to the manufacture of paper. When the log reaches the mill it is first dragged out of the water by iron dogs and rolled and slid to a great circular saw that cuts it into lengths. At the same time, a "barker," made of rapidly rotating blades, removes the bark from the log with the most tremendous noise. The buzz-saw is supposed to emit one of the worst noises that ever afflicted human ears, but the barker can outscreech three large buzz-saws, and when several saws and barkers are operating together the noise is so deafening as to be beyond the writer's powers of description.

The short lengths of logs when bared of bark are ready for the grinders. In these the wood is pressed hard against a grind-stone under a constant flow of water.

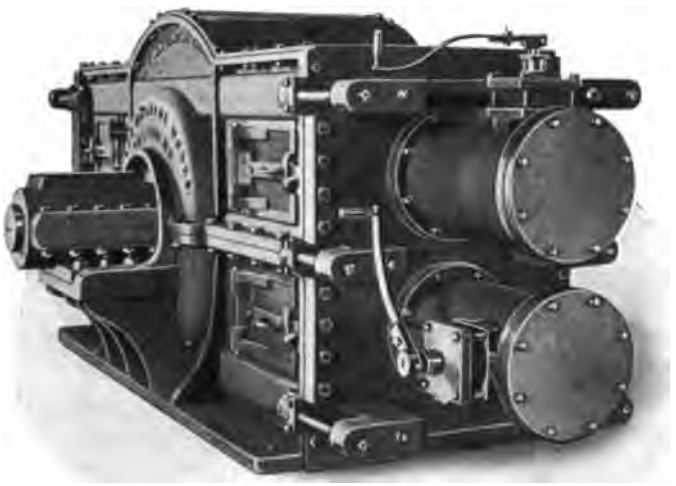
The Dilts New Century Pulp-Grinder, here illustrated, made by the Dilts Machine Works, of Fulton, New York, has four pockets or receptacles for the wood, provided with doors as shown. For each pocket there is a hydraulic cylinder with piston, piston-rod, and follower.

The wood, in blocks twenty-eight inches long and twelve inches or less in diameter, is placed in the pockets in front of the followers. The valves on the cylinders are then thrown open and the wood is forced by hydraulic pressure against the revolving stone, which grinds it to pulp. The pulp is then carried by flotation to the wet machines, which form it into a sheet.

The New Century grinder differs from other makes in several respects. The pockets, instead of being over the top of the stone, are arranged two on each side of the stone; the pressure from grinding is thus balanced between the two sides of the stone, and

there is no undue strain on the bearings as is the case when the pockets are placed above.

The construction is very simple. Heavy side frames support the machine and have brackets for carrying the stone shaft. These side frames have grooves planed on the inside surfaces, and in these grooves are supported the grinding plates which form the horizontal walls of the pockets. These grinding plates are adjustable close to the stone, so that no slivers can be made. The grinder stone, which is fifty-four inches in diameter, is carried on a hammered steel shaft supported in water-cooled bearings. On each side of the stone are very heavy iron collars, which are threaded on the shaft in such



The Dilts New Century Pulp-Grinder.

manner that they hold the stone securely, and at the same time can be easily removed.

The ground pulp so made is called "filler," which constitutes about seventy-five per cent. of the material used in paper-making. The grinding of the wood tends to destroy the fibre, and for that reason in manufacturing the better grades of wood-paper a chemical process is employed, commonly known as the sulphite process. For this the logs are reduced to chips by a machine having rotating knives, and called the chipper. This reduces the log at a rapid rate, and the stream of chips is transported by an endless carrier to the sulphite-mill to be digested. The digester is an enormous steel tank

or boiler, lined with tile or the like to prevent the acid from eating into the steel sides. Some of these digesters are large enough to hold forty cords of chips at a single loading. Into the top the chips are dumped, after which the top is closed and the steam turned on, and the whole cooked at a temperature of perhaps 400° F. for about eight or ten hours. The digested material is taken out through a manhole at the bottom of the digester, and strained to remove any coarse particles of foreign matter, then pressed to exclude surplus water, after which it is ready for the paper-mill. The material obtained by this sulphite process being made from the chips retains longer fibres when reduced to pulp than does that which is ground, and it is this fibre which, entering into the finished article, gives added strength to the paper.

Next the pulp is pumped up to the " wet end" of the machine. Paper-makers call one end of the long paper-making machine the " wet end" and the other the " dry end." First at the " wet end" is the screen, a box-like arrangement where the pulp is screened of all slivers and particles too large to knit into the paper fibre. From the screen it flows into the head box, which is a contrivance that automatically governs the head or flow of pulp upon the machine. This flow has to be nicely adjusted. The flow must be just right for the sheet of paper to be of the right thickness. From the head box the pulp flows out with the wood fibre held in such thin solution that it looks like very thin milk.

The standard width of the wet machine is seventy-two inches face of press-rolls. The cylinder vat into which the stock is received is substantially made of lumber. It supports the cylinder-mould on which the sheet is formed, and has partitions for directing the flow of stock evenly and uniformly over the face of the mould.

The cylinder-mould is a roll built of bronze spiders mounted on a steel shaft, and covered with brass rods running longitudinally, secured by a close winding of hard copper wire. Outside of the wire winding are two faces of brass wire cloth, fine enough so that the pulp cannot pass through them, though the water can readily.

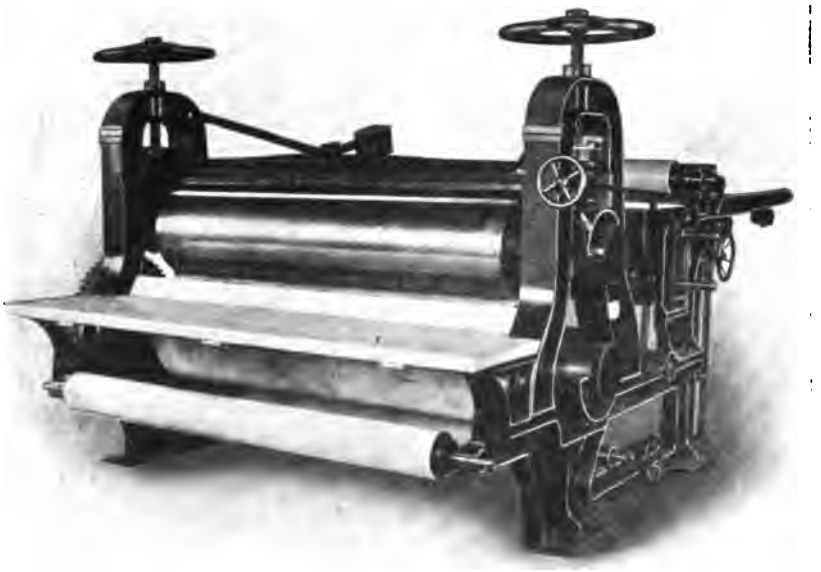
The couch-roll shown in the cut at the top of the vat may be either rubber or wood covered. From the couch-roll the endless felt carrying the newly-formed wet sheet of pulp passes first over the suction-box, then over the guide-roll, and between the press-rolls. The pulp adheres to the upper press-roll, where it is allowed to accumulate to a sufficient thickness, and is then cut off.

After depositing its burden of pulp, the felt is beaten by the felt-beater, sprayed by the shower-pipe, squeezed by the squeeze-

rolls and stretched by the stretchers, and freed from all adhering particles of pulp, partially dried, and, guided straight in its return course, it passes again to the couch-roll.

The Dilts No. 3 Wet Machine is shown in the illustration. The course of the felt is straight and direct, and this machine is so arranged that the felt can be quickly and easily replaced.

In another form of machine the pulp flows on to an endless wire straining-cloth that permits the running off of a large portion of the water. This cloth is guarded on the sides by endless bands or



The Dilts Wet Machine.

deckles that run under the dandy-rolls of the machine. These rolls carry the wire-cloth, and any particular pattern of wire will produce a corresponding water-mark. The arrangement of the wires at the dandy-roll also serves to determine whether the paper is of the character technically known as "laid" or "wove." While the film of pulp is travelling to the apron it is subjected to a side-shaking in order to cause the fibres of the pulp to cross each other.

After passing the dandy-roll, a save-all box catches and preserves the water that drains off, in order to save any size or coloring-

matter that it contains. The film of pulp passes on to the couch-rolls, and thence to an endless wet felt apron, on which it rests while carried between a pair of rolls, by which it is transferred to the press-felt apron, and passes to the pressure-rolls. These rolls press out nearly all the remaining water and bring the pulp film almost to the condition of paper. From this point, the paper, as it may now be called, is able to carry itself without a blanket support, and is directed on between various drying and calendering rolls, some of which are heated in order to take out any remaining dampness from the paper. As it emerges from the machine, the paper is wound up in enormous rolls, often a mile or more in length.

About 20,000,000 pounds of paper a day are manufactured in the United States, this being greater than the total output of the mills in all other parts of the world. A little more than a quarter of this goes into the newspapers of the country, a little more than one-eighth into books and magazines, and about one-twentieth part into writing-papers. The remainder is made into wrapping-papers and paper-boards, as for boxes and similar purposes.

In 1891 the *Philadelphia Record* made a test as to the speed with which a tree in the forest could be converted into a newspaper ready for sale. The concern owned a paper-mill, and so was able to carry out the experiment satisfactorily. The time from the putting of the axe to the tree to the offering of the newspapers on the street was twenty-two hours. This record has been surpassed since in Germany, presumably in a place where the mill and printing-press were in the same establishment or close by.

There are several Sunday newspapers in the United States that consume as much as a hundred tons of paper in printing a single issue, thus consuming about 125 cords of wood and clearing off about six acres of well-grown spruce timber land.

Japanese paper is a distinctly different product from American-made paper. It has a strength of fibre unknown here, and is superior in many ways, as well as much more costly, being hand-made. They use the bark of plants, as the kodzu, cutting it into strips of perhaps a yard in length, which are tied up in bundles, and then softened in water containing a weak solution of lye. The next process is treatment with a special form of mallet for separating the strips into fine fibres, and this is done with a care that secures a much longer fibre than is had in American manufacture. In making the paper, they use instead of the animal glue, which has such a rank odor, a cement made from the roots of a native plant. The pulped fibres are spread on a sieve to level out the mass by shaking

and let the water drain off, much as we do in making paper by hand, after which it is rubbed on a board with a soft instrument, and dried in the sun, when it peels off the board as a sheet of remarkably tough paper. It is this sort of paper that the Japanese use for window-glass, and it is also twisted into threads of great strength that are used in embroidery and ornamentation. This paper is also specially adapted by its porous quality to use for writing on with India ink and a brush, and also for native painting.

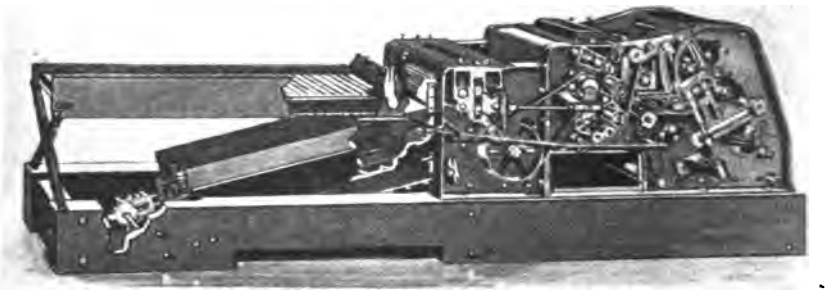
Courtesy Jeffrey Manufacturing Company.

A Log Haul-up at a Lumber-Mill.

The methods employed for testing paper, in order to judge accurately of its quality and value, are both mechanical and chemical. For determining the thickness and consequent weight per ream, a

micrometer gauge is applied to a number of samples, which are weighed, and the calculation usually reduced to the weight per square foot. For determining the strength of paper, a dynamometer is employed that records the weight at which a strip of paper breaks under strain, and also the amount of elongation before rupture. In making this test, strips are cut from the paper, both in the direction of the fibres and across the grain. The latter strip of paper is the weakest. Tests for friction are usually made by hand, folding and unfolding the paper, and noting how many times it can be creased before breaking, and also by alternately crumbling the paper and smoothing it out.

In order to judge of the sort of fibre used in a paper, it is cut in strips and boiled in a one per cent. caustic solution. When it is sufficiently pulped it is collected on a wire gauze and examined under



Machine for Reducing the Indian-Corn Plant for Paper-Making.

the microscope. If the fibres appear brown they are either cotton, hemp, flax, or ramie; if yellow, jute; if no color is apparent, it is either wood- or straw-pulp or alfa. Straw is detected by the oblong cells in the fibre showing under the microscope, while alfa exhibits very fine fibre and saw-teeth, cotton resembles a ribbon with swellings and spirals, and wood has transparent wide and flat cells.

As most paper is made of wood-pulp, and its quality is usually improved by the addition of stronger fibres, it is often desired to determine the amount of wood-pulp in a given paper. This is done by dipping a sample of the paper into a mixture of hydrochloric acid and phloroglucine dissolved in alcohol, when the wood-pulp reveals a rose color—the rosier the tint the greater the quantity of wood. There are sometimes free acids in paper, which are damaging to its quality, and these may be detected by burning the paper and analyzing the ashes.

Sizing is tested to discover fecula or starch, also for resin and for gelatin. When the paper is dipped in a dark solution of iodine the starch in the sizing will turn blue; when ether is dropped on the paper, if there is resin in the sizing, it forms an aureole within a dull circle; the gelatin test consists in boiling water, filtering the pulp, and treating with tannin. To discover whether the sizing on the paper covers it properly on both sides, a solution of iron is allowed to flow across one side of the paper in drops so that it forms a number of wet lines across the sheet. A solution of tannin is then flowed across the other side of the paper, so that the wet lines cross each other. If the sizing is inadequate at any point where the lines cross, the solutions will mix and form a blot.

THE WONDERFUL INSTRUMENTS OF SCIENCE

THE work of the scientist of one decade is often the work of some industry in the next, for to the men who study nature's laws, largely from pure love of finding out her secrets, every industry is indebted in large measure. It is therefore difficult to separate the instruments of science from the instruments of trade, but the endeavor is made here, largely for the sake of covering those instruments of a more or less scientific character, which are not mentioned or described in some other portion of this work.

Equatorial Telescope, Lick Observatory.

The instruments of the astronomer may be classed as purely scientific, since they are used wholly in the pursuit of knowledge. The telescope being the astronomer's principal instrument naturally

comes up first for consideration. It is manufactured on two distinct and different principles, one being termed the refracting telescope and the other the reflecting. In the refractor, a lens or object-glass brings the rays of light to a focus, where they are viewed by an eyepiece that is virtually a microscope. In the reflector, a great concave mirror is used to catch and reflect the image.

Among the largest and most successful refracting telescopes, which are the sort most in use, are the Lick telescope located at the observatory on Mount Hamilton, California. This has a focal length of fifty-seven feet and a fifty-two-foot tube, the object-glass being thirty-six inches in diameter. It was the largest in the world at the time it was built, and, owing to its superior location on a mountain in a rarefied atmosphere, is still the best equipped for difficult feats of seeing, and the observing of minute objects, as the fifth satellite of Jupiter, which was discovered through its use. Probably this telescope has added more to the sum total of the astronomer's knowledge than any other one instrument that could be named.

Of greater size, but less fortunately located than the Lick, is the great Yerkes refractor, at Lake Geneva, Wisconsin. The lens of this instrument is said to have cost $100,000, and it is mounted in an 85-foot dome. The supports and mechanism are of course very heavy, the driving-clock alone weighing 3000 pounds and the hour-axis three and a half tons. The object-glass of the Yerkes telescope is 41⅜ inches in diameter, and the focal length is sixty-five feet. Only two larger object-glasses have been made, that of the telescope of Gruenewald shown at the Berlin Exposition, which was forty-three inches in diameter, and a lens completed by John Peate for the American University at Washington, D. C., which is sixty-two inches in diameter.

The reflecting telescope styled the "Grande Lunette," shown at the Paris Exposition of 1900, is the most remarkable instrument of its kind. The tube is 197 feet in length, and the lens fifty inches in diameter. The tube is permanently mounted on a row of stone piers. The glass mirror, which is seventy-nine inches in diameter and weighs almost four tons, is placed at an angle at one end that it may receive the reflections and throw them down the tube. In order that the mirror may be turned easily, it is floated in a bath of mercury. The siderostat is mounted on a massive iron frame, and by means of clockwork causes the mirror to follow the motion of any star that has been selected for viewing. The entire cost of this instrument is stated as $400,000.

The refracting telescopes are, as a rule, mounted equatorially,

that is, so that they can be turned with the motion of the earth's equator, and thus be kept fixed on a point in the heavens, as when taking a photograph that requires a long exposure. It is believed that the limit of size of this sort of telescope is about reached, as the immense weight of the tube makes it difficult to preserve exact

Courtesy Munn & Company.

The "Grande Lunette" Reflecting Telescope.

alignment, changes of temperature or the slightest strains affecting the accuracy of the whole structure.

Reflecting telescopes are more commonly built with an immovable supported tube, as the "Grande Lunette" described. A notable exception, however, is the Crossley reflector, located at the Lick Observatory, and the largest instrument of its kind in America. It has a three-foot mirror, and is mounted equatorially, without any tube, in the manner readily apparent from the illustration. It

is provided with a driving-clock similar to that of the large Lick refractor. This reflector is used mainly for photographic work, and has been used very successfully in photographing nebulæ. Each photograph taken with it usually yields several new nebulæ to be added to the recorded list, as many as thirty-one having been discovered on a single plate. Professor Keeler estimates that there are at least 120,000 nebulæ within the reach of the reflector. Stellar spectroscopy is also a fruitful field of research for this instrument.

The spectroscope, used with the telescope, is responsible for a very large share of the increased knowledge of the universe. A spectrum is an image of dispersed light, as thrown on a screen by a prism through which a ray is directed, and its light dispersed. A spectroscope is an instrument for spectrum analysis. It has a collimating lens; that is, a lens set in a tube with a slit at its focus, so that the light passes through the lens, the slit, and then the prism; after passing these the light continues through a train of prisms in a semicircle to a point where it forms a spectrum and may be viewed with a small telescope. The more prisms there are used in a spectroscope, the wider is the dispersion of the rays and the more easily are the lines of the spectrum studied. By using a very finely-ruled grating, called a diffraction grating, diffraction spectra may be obtained, and with a Rowland concave grating a real image may be obtained for throwing on a screen or photographing.

By studying the lines of the solar spectrum it has been determined that the elements we have on the earth, as iron, mercury, hydrogen, oxygen, carbon, etc., exist also in the sun. This is known positively, because when a metal, as mercury, is heated red hot, so that it begins to vaporize, and its spectrum is studied, it is found to exhibit certain lines, which lines are duplicated in the solar spectrum. In this way it has been determined that the stars generally are made of the same elements or materials as the earth, differing, however, in various respects, so that they are classified by astronomers according to the nature of their spectra. Our sun is classified in a group noticeable for the prominence of metals; another group includes luminous bluish-white stars, having spectra rich in blue rays, marked by dark lines due to hydrogen, and so on.

One of the most wonderful things learned by the spectroscope is the motion of particular stars. Though a single star throws a very faint light down the tube of a spectroscope, yet in many cases the spectrum obtainable is sufficiently clear to exhibit a shifting of the lines. When the star is moving towards the observer the lines tend to shift to the blue end of the spectrum; when the star is

moving away, they shift to the red end; and the amount of the shifting is a measure of the speed of motion. A star coming towards us grows more orange or red, and a star going away appears more bluish. A study of the motions of stars, as learned from the spectroscope, has led astronomers to state the speeds of motion of certain stars as so many miles per second with the assurance that they could not be mistaken in the speed more than one per cent.!

The Crossley Reflector.

Dark stars—that is, stars that give out no light, and which it might naturally be supposed we would never learn of—have been discovered in considerable numbers by means of the spectroscope. This remarkable result has been attained by observing the motion of certain stars, which sped towards us and from us in regular periods, that showed them to be moving in orbits around or influenced by some other body that was invisible. That a human being should be able to know of the existence of a non-luminous star

countless millions of miles away, and to state certainly something as to its probable size, weight, and motion, is a triumph of mechanism and intelligence unsurpassed by any other achievement of the human race.

A most interesting device for demonstrating to the vision of spectators the fact that the earth rotates was made by Foucault in Paris, in 1851, the idea of the apparatus having been suggested by Galileo in 1601. The apparatus was reconstructed, and the experiment tried again in the Paris Pantheon in 1902. It is based on the principle that a swinging pendulum tends to continue its vibrations in the same plane, so that though the earth may shift in position because of its rotation, yet the pendulum swings on, appearing to alter its direction of motion. In the 1902 experiment a piece of

Astronomical Observatory, Harvard University.

piano wire, two hundred feet long, was hung from the top of the Pantheon dome; at the end was hung a fifty-pound ball of lead, with a steel needle or pointer protruding from the lower side. Fine sand being spread over the floor, the ball was hung so that as it swung it faintly traced its movement in the sand. The ball was tied to one side with a thread, which was burned away by the flame of a match, as shown in the illustration. The movement of the pendulum was started in this way to insure against any accidental side vibrations in starting by hand. A large concourse witnessed the swinging of the pendulum, and at each passage across the sand it marked out a new line, slightly different from the previous one, showing the extent of the earth's rotation during the period of the pendulum's beat. After a time, the pendulum's course so changed

that it was swinging at right angles to the original swing. Any one who will take the trouble to take a ball, and mark the poles on it and the assumed position of Paris, and then hold a sheet of paper in a given plane perpendicular to Paris on the wall, and turn the ball around, just as the earth turns on its axis, can figure out for himself the changing of the position of the pendulum, which continues to swing in the plane of the paper.

The talking-machine belongs naturally under this chapter, though it has its commercial and amusement purposes. Thomas A. Edison is the father of the phonograph. Noting the crudity of the phonautograph, an instrument invented by Leon Scott for re-

Courtesy Literary Digest.

Pendulum Experiment for Proving Earth's Rotation.

cording the vibrations of sounds, he conceived the idea of reproducing the human voice or other sounds by causing a bristle on a vibrating diaphragm to indent a coated cylinder. The cylinder thus securing a record of the vibrations of the voice was made to reproduce them by causing the diaphragm to be vibrated again as the cylinder was rotated. In other words, the simple reversal of the recording mechanism reproduces the voice. The second phonograph that he built was very much like the instruments in use today, except that now they are better made, and have many minor devices insuring smooth working and more distinct reproduction.

The wax cylinder, as a substitute for a tin-foil surface, was invented by Bell and Tainter, and McDonald and many others made later improvements. The waxy surface of the cylinders, which is really a sort of toughened soap, is melted in a cauldron and moulded on the cylinders, which are turned off in a sort of lathe to insure accuracy of surface. It is apparent that the records of songs, speeches, and the like have to be duplicated in a cheap manner to render them available for general use. If a famous singer had to sing a song through every time a record was made, it would cost as much for the record as to pay for a box-seat at several performances by the same singer. An apparatus is therefore used which enables an original record, specially well made, to serve as a guide for a stylus to cut duplicate records in other cylinders.

The gramophone is a machine somewhat similar to the phonograph, invented by E. Berliner, and employing a rotating disk instead of a cylinder for the record. The graphophone is the name given to an improved form of phonograph, using either a disk or a cylinder. The complication of names is unnecessarily confusing, as there is also the telegraphone, applied to those forms of the instrument wherein the sound is transmitted to or from the diaphragm though a wire, water-tube, etc., connecting with the stylus.

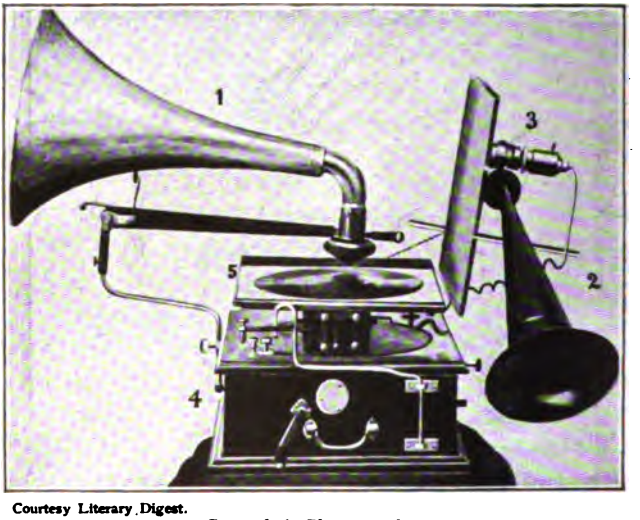
The substitution of paper for metal in the speaking-horn and parts leading to it have resulted in reducing the brassy sound, which is objectionable in many instruments. M. Burguet, a French inventor, a few years since devised a new diaphragm calculated to render a more perfect imitation of the natural tones of the voice. He uses a mica diaphragm, which has a series of little rods connecting with the central stylus in such a manner that the vibrations of the voice alone affect the stylus, the vibrations incidental to the diaphragm itself not affecting the little rods. This prevents distorting metallic sounds.

A phonograph that will reproduce its records photographically has been constructed by Emanuel Cervenka, a Bohemian. The vibrations of the diaphragm are used to vibrate a little mirror, which reflects a pencil of light on a cylinder covered with a sensitive gelatin film, thus producing a photographic sinuous line on the cylinder, the equivalent of the usual curved line of a record. By treating the gelatin after the manner well known to photo-engravers, the line can be made either a groove, as in an ordinary record cylinder, or can be made elevated.

In 1900 there were eleven establishments located in seven different States in the country manufacturing phonographs and

graphophones, having a capital of $3,350,000, and producing $2,250,000 worth of instruments and apparatus yearly. The industry gives employment to 1400 men, and they made 151,000 machines during 1900, besides nearly 3,000,000 records.

The total result of these inventions and their manufacture on a large scale is that talking-machines can be bought from $5 up to $150, and records from twenty cents each up to $3. An ordinary cylinder record will hold an average of a thousand words, the equivalent of about two pages of this book. While the phonograph is principally known as a means of reproducing for amusement, it has an important and growing use as a medium of dictation. The busy man dictates his letters or articles into the phonograph as



Courtesy Literary Digest.

Cervenka's Phonograph.

fast or as slowly as suits his convenience, and his typewriter, who need not be a stenographer, reproduces them more accurately and easily than is possible with oral dictation, as the phonograph can be set going at any pace, and can be made to repeat without difficulty or annoyance.

The acoustiphone of H. G. Pape is a new invention intended to assist or improve telephoning. By its use all the conversation in a room can be heard at a great distance, and it has such good acoustic properties that the inventor expects it to make the telephone available for the deaf. It is a sort of simplified acousticon, or instrument for reporting a concert or the like to a listener located at a distant 'phone.

A talking mechanism based on altogether different principles has been produced by Dr. R. Marage, a French scientist. He has made a series of plaster casts representing heads and having apertures of different sizes. By blowing air through one he gets the vowel " a," another " e," another " i," and so on, and by working them in combination they produce words and sentences. The operation is purely mechanical, based on the theory that language is a modification of utterances of the five vowels.

Marage's Talking Casts.

The akouphone and the acousticon are instruments noteworthy in this connection, their object being to assist the partially deaf in hearing. They are designed to emphasize articulation by magnification, so that a whisper is made to be readily heard and understood by any one whose hearing is not totally destroyed. They are especially useful for deaf-mutes, being based in principle upon the microphone and having a pocket battery to furnish the current for increasing the sound.

In the field of optics the series of instruments based on Edison's kinetoscope, which have given to the world the moving pictures, are easily the most important of recent years. Every invention has a forerunner, and the kinetoscope is a development of the phenakistoscope, but about as superior as a live monkey is to a toy jumping-jack. Edison has been criticised because his inventions are mainly improvements of what some one else began, but such criticism exhibits the small mind. Edison bettered every field of mechanism that he touched, and made modern marvels out of useless toys, as in the present instance; he deserves all the credit he has received,

even if he did have to turn over the detail of very much of his work to trained assistants. No other man has done more than he to make this the age of electricity.

The phenakistoscope can be made of card-board by any one, and serves rudely to illustrate the basic principle of moving pictures It has a disk on which are mounted, say, ten pictures of a girl jumping a rope, the pictures showing ten successive positions. A larger disk rotating outside of the picture disk has radial slits through which the pictures can be seen. When the two disks are rotated before a mirror the observer may look through the slits and see the reflection of each picture in such a way that it appears as one picture of a girl jumping the rope.

What Edison did was to substitute a photographic film for the pictures, devising a means of taking the photographs of a moving subject at the rate of forty-six a second, a rate never previously obtained, and to reproduce these pictures by throwing them on a screen, where they appeared as one moving picture. He was followed by a host of minor inventors who produced the biograph, cinematograph, etc., these being machines for reproducing the pictures. For an explanation of the manner in which trick moving pictures are produced, see the chapter on "The Machinery of Amusement."

Instruments for utilizing or exhibiting the X-rays discovered by Roentgen have been developed to a high degree. These rays have always existed, so far as we know, just as have light rays, yet our eyes do not appreciate them; but by passing them through a fluorescent screen they develop light, and it is thus we are able to see the bones of a hand in an X-ray apparatus. The X-ray affects photographic plates, and enables the photographing of the interior of a human being, finding its most important use in enabling the surgeon to locate a bullet, a fractured bone, or the like.

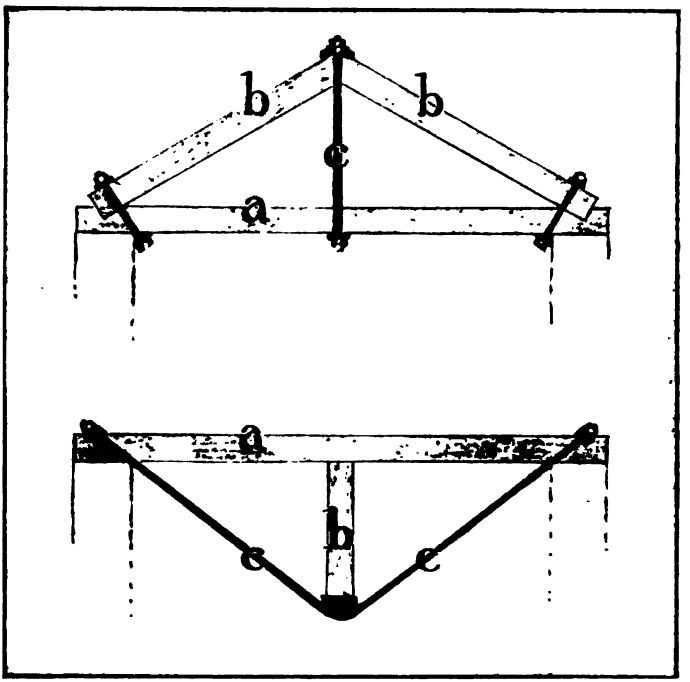
The method of taking an X-ray photograph consists in placing the object to be photographed, as a man's foot, between an X-ray tube or bulb and a sensitized plate, so that the rays emanating from the tube will pass through the foot, and be intercepted by the bones or any mineral or dense substance, photographing the same on the plate. The X-ray tube, which is based on the Crookes tube, is made in several forms, being a glass bulb, in which as perfect a vacuum as possible is produced, and the positive and negative wires of a battery or other electric source connected to the tube so that they may form a spark across a gap in the vacuum. Inside the tube is a deflecting plate of platinum, through which metal the rays do not

pass, but which deflects them, directing them towards the photographic plate, this method securing a sharper shadow than where the platinum plate is omitted.

The fluoroscope for observing the rays visually is a dark box with a place to apply the eyes, and a screen covered with a layer of fluorescing material, as calcium tungstate or fluoride of ammonia and uranium. The inside of the box is blackened, and the screen larger form of fluoroscope is used for exhibition purposes. See illustration, page 31.

BRIDGES—BIG, LITTLE, AND PECULIAR

BRIDGE construction has ever been one of the most interesting branches of engineering science. The problem of building a heavy roadway over a long span and giving it sufficient strength, not only to hold up its own weight, but to support a crowd of vehicles and people, is one that has been met successfully in many ways, and there are few instances where great bridges have given way through any fault of the designers. The great gains made in the



Principle of the Bridge Truss.

strength of steel-wire cables within recent years have made it possible to build larger and larger bridges with greater and greater reserves of strength. When iron came into use, stone was still used for the supporting piers and towers, but of late steel construction has made such gains that it is now becoming the practice to build the towers and even parts of the piers of steel.

As named from their method of construction, bridges are

known as through-bridges when the roadway passes between the system of trusses, and as deck-bridges when the deck or roadway is on top of the trusses. A bridge having an arched truss above the deck is called a bow-string bridge from its form. When the girders are crossed it is known as a lattice-bridge. Bridges are also named from the nature of their supports, as pile-bridge, trestle-bridge, etc.; or the nature of the draw, as hoist-bridge, lift-bridge, swing-bridge, turn-bridge, etc. By far the greatest number of bridges built to-day are constructed of steel trusses, the principle

Cantilever Bridge at Niagara.

involved being the crossing or bracing of rods in such a manner that the strains are received lengthwise instead of crosswise. A few simple forms of trusses are shown in the accompanying drawings.

The truss, which embodies the fundamental strength-giving feature in a great majority of bridges, is simply an arrangement of metal bars and rods, so braced as to give the greatest resistance to the strains. Reduced to its simplest proportions, it may be illustrated thus: *a* is the bridge floor, *b* and *b* are compression members, and *c* is a tie-rod or tensile member. The weight on *a* is supported

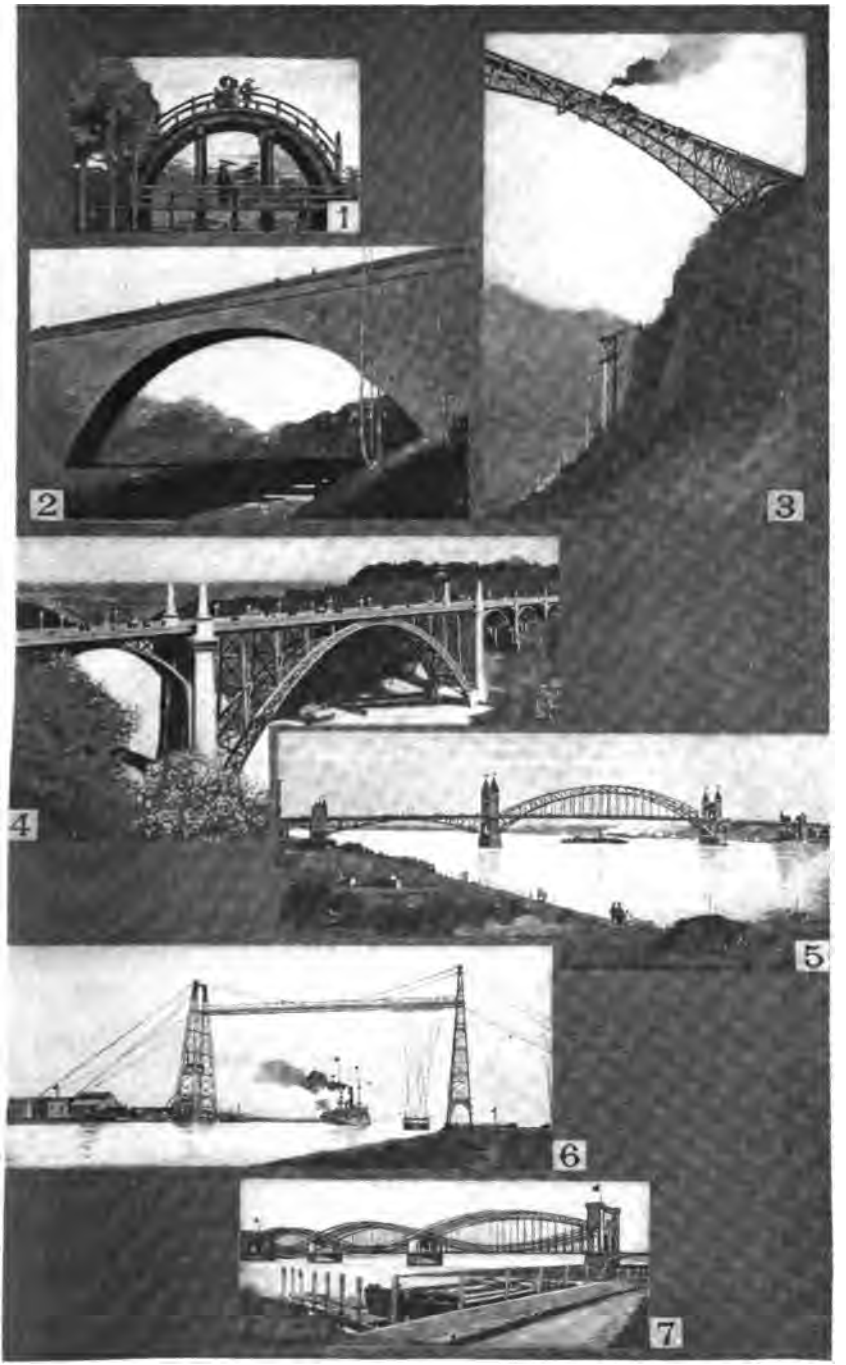
at *c*, causing a downward pull that tends to compress *b* and *b* in the direction of their lengths. The resistance of a rectangular or an angle bar to such compression is very great, hence an enormous weight can be supported by materials which would readily break if laid flat in the form of *a*. The same result can be obtained by reversing the truss, as in the lower diagram, where *b* becomes the compression member and *c* and *c* are tie-rods.

Practically all bridges were built of wood or stone prior to 1779, when the first iron bridge was built in England over the river Severn, where it still stands to-day, the place being known as Ironbridge. The first suspension bridge was the famous Menai Straits bridge, erected in North Wales in 1826, and costing about $100,000.

Halstead Street Tower Bridge, Chicago.

Great iron chains were used to hold up the bridge, the main span being 579 feet long. A few years later there was built at Fribourg, in Switzerland, the first suspension bridge having iron wires for supporting. The most important cantilever bridge is that over the Firth of Forth in Scotland. In most respects this is the biggest bridge ever built, employing more metal for the work accomplished than any subsequent bridge.

In describing a number of the larger bridges, it is well to take the Firth of Forth bridge as a starting-point, in order to note the improvements. This bridge was designed on the cantilever principle, which consists in extending the girders in both directions from a pier, hanging them to a short tower on the pier. In this way they



1, Wisteria and First Bridge Temple, Tokio, Japan; 2, Cabin John Bridge, Washington, span. 220 feet; 3, view of the Great Rio Grande braced arch bridge from underneath; 4, new arch bridge across the Aare, at Berne, Switzerland, main span 376½ feet in length; 5, the beautiful steel bridge at Bonn, with piers designed to match the medieval castles of the Rhine, main span 616½ feet long, two side spans each 113 feet long; 6, the ferry-bridge at Bizerta; 7, the North Elbe bridge, Hamburg; each of the main spans is 325 feet in length.

balance each other, so that if there are several piers in a bridge, each pier supports half of the span on either side of it, and is perfectly independent of the other piers. The Forth bridge is 8296 feet long over all, and its longest cantilevers are of 1700 feet span. Owing to the inferior strength of the metal obtainable at that date, it was necessary to make the towers 360 feet above high water in order to secure sufficient leverage to brace the structure properly. A single span of this bridge weighs 17,900 tons; the principal compression members of the cantilevers are tubes of twelve feet diameter, which tends to give an added appearance of weight and clumsiness to the bridge.

The Brooklyn bridge which connects New York and Brooklyn, opposite City Hall, New York., was completed in 1883, and is very superior in design to the Forth bridge. Its extreme length is 5989 feet, and the main span, measuring from centre to centre of supports, is 1596 feet, so that in size it compares pretty nearly with the Forth bridge. The average weight of the superstructures per lineal foot is 7400 pounds, which is only forty per cent. of the weight of material in the Forth bridge. The money cost of the two bridges was about the same—between $12,000,000 and $15,000,000—although the actual cost of the Brooklyn bridge is believed to have been about one-half, the remainder being used up in financiering. The towers of the Brooklyn bridge are made of masonry, and stand 278 feet above high-water mark; the tower on the New York side, whose foundations are deepest, contains 47,000 cubic yards of masonry. The roadway is eighty-five feet in width, and includes a double track for cable-cars, two tracks for trolley street-cars, two roads for wagons, and one footway or promenade.

In the present year, 1904, there is nearly completed another bridge over the East River, extending from near Grand Street, in New York, to the northern part of Brooklyn, locally termed Williamsburg. This bridge marks a considerable advance over the older Brooklyn bridge. Its towers are built entirely of steel above water, and its main span is 1600 feet long. It is in the carrying capacity that the Williamsburg bridge chiefly surpasses the bridges previously mentioned. Its roadways have a total width of 118 feet, which is nearly three times the width of the Forth bridge roadway. In the centre is a promenade for foot-travellers, and on each side of this are double railway tracks, and beyond these two 18-foot roadways for vehicles. Above the first roadway is a double bicycle-way, with a space for foot-travellers between. On yet a third level are tracks for bridge-cars. The roadways and tracks rise from the

Comparison of Bridge Towers over East River, New York.
1, Blackwell's Island Bridge; 2, Williamsburg Bridge; 3, East River Bridge.

approaches at a gentle grade to the highest point at the centre of the bridge, where they are 140 feet above high-water mark.

The next step in advance of the Williamsburg bridge is well marked in the bridge under construction a few miles north, crossing the East River at Blackwell's Island. The total length of this bridge is 7636 feet, or longer than any of those so far discussed. Its spans are shorter, however, being 1182 and 984 feet in length. This bridge is to be completed in 1906 at an expected cost of $12,500,000. Its construction is novel in that it includes elevators and stairways at the central pier on Blackwell's Island. Having shorter spans than the before-mentioned bridges, the towers are of less height and the strains on the material considerably less.

The principle of a suspension bridge is simple suspension of a roadway with wire cables hung over towers. This bridge substitutes eye-bars for wire cables, and engineers have severely criticised this feature, on the ground that such will involve more weight for the same strength, but the engineers who designed the bridge claim that their figures prove that this is the lightest construction possible under the existing conditions. The quality of the steel used is unsurpassed in any bridge up to this date. The nickel-steel eye-bars have an ultimate strength of 90,000 pounds to the square inch, and an elastic limit of 54,000 pounds to the inch. This steel is probably twice the strength of that used in the Forth bridge. The design calls for ability to carry 12,600 pounds of live load per lineal foot, this being the estimated extreme strain that can be applied at a time of congested traffic. The width of the structure from the centre of the side members is sixty feet, giving an interior roadway of fifty-five feet. Since there is a double deck and outside car-tracks, the total roadway is perhaps a little greater than that of the Williamsburg bridge, giving it the greatest transporting capacity of any bridge in the world. There are six car-tracks in all, and a roadway of thirty-six feet and two footways of eleven feet each. These footways have a supporting strength of several hundred pounds per square foot, and the grade is three and a third feet in each 100 feet.

A comparison of the towers of these bridges between New York and Brooklyn affords a good illustration of the advances made in construction, the towers of the later bridges being both lighter and stronger than the earlier ones. The principle of support in all these bridges is the same, great steel cables being anchored deep in the ground on either side of the river and hung over the tops of the towers in such a manner that the roadways are attached to the depending loops or curves. Each bridge has four cables, two rest-

ing on each tower, and the strength of the cables is estimated to be five times as great as any strain to which they could possibly be subjected. These bridges exceed in general dimensions and capacity any bridges anywhere else in the world. It is true that there are some longer bridges, but these have more numerous piers, so that they do not permit vessels of any size to pass underneath. An instance is the iron bridge at Dundee, Scotland, over the river Tay, which is 10,612 feet in length, but has continuous supports, and cost less than $2,000,000. It is just fifty-two feet longer than the bridge

Courtesy Scientific American.

Spiral Approach to High Bridge, Hastings, Minnesota.

over the Ohio River at Cairo, Ill. This latter bridge has fifty spans, and 21,000,000 pounds of steel were used in its construction, besides 32,000 cubic yards of masonry.

Sometimes the peculiarities of a location induce the building of an engineering oddity in connection with a bridge. A case in point is shown in the illustration of the bridge across the Mississippi at Hastings, Minnesota. The conditions were that this bridge should be placed seventy-five feet above low-water mark, and as this necessitated a long raise in the approach, and it was desirable to bring the approach close to one end of the bridge, the idea of a spiral roadway suggested itself to John C. Meloy, who donated the ground for this curious structure. The spiral is a complete success, and is used continually by heavy teams that find the grade an easy one.

This is the only free bridge between St. Paul and Dubuque, Iowa, and was completed in 1895.

Other notable bridges in the United States are at Memphis, Tennessee, where there is a cantilever bridge whose longest span is 720 feet; the Bismarck bridge over the Missouri at Bismarck, North Dakota, having three spans of 400 feet each; the Niagara cantilever bridge, having cantilevers 395 feet long; the Schuylkill arch-truss bridge, having a single span of 340 feet, which was probably the longest at the date it was built in 1812; the Washington bridge over the Harlem River at New York, having a total

Washington Bridge, New York.

length of 2380 feet; the Cincinnati bridge over the Ohio, having a main span of 1067 feet; the Poughkeepsie bridge across the Hudson, which is 3094 feet long and has three spans, the longest of which is 548 feet; and the three-tower suspension bridge at Easton, Pennsylvania, built over the Lehigh River in 1901.

Stone arch bridges are quite as remarkable in their way as the steel suspension bridges, although their spans are necessarily shorter. The longest single span built of solid masonry is over the Petrusse River, in Luxemburg, Germany, this bridge being opened in 1903. The arch is 275½ feet inside measurement, and the roadway is 145 feet above the water, the river being a small

stream running in a gorge. Nearly 800,000 cubic feet of masonry are used in the structure, and the cost is about $275,000. The longest masonry arch in United States is that of the Cabin John bridge, near Washington, D. C., which has an arch 220 feet long, leaving a clear space below of fifty-seven feet. Over the river Pruth in Galicia is a railway bridge having a single stone arch of 213¼ feet. It is constructed of sandstone and cost only $40,000.

London has no very remarkable bridges, because the Thames is not a wide river. The most conspicuous is the tower bridge, which is 2640 feet long and has a roadway sixty feet wide. The longest span is 270 feet, and the height above tide-water only 29½ feet. In the central span is a lifting draw, somewhat similar to that described farther on in this chapter.

The problem of providing room for vessels to pass through

Victoria Tubular Bridge, Montreal, Canada.

under a bridge is always a troublesome one for the engineer. To build the bridge high enough to allow large vessels to pass underneath is usually prohibited by the expense involved, and it becomes necessary to devise some form of draw or opening for the passage of vessels. The old-fashioned draw was, as its name implies, provided with a mechanism for drawing back or apart the opposed ends of a bridge. This was not adapted to a long opening, and was soon superseded by the swing-bridge, having a central span that rotated, leaving an opening on either side.

This has been the commonest method, but bids fair to give way before the rolling lift or bascule bridge. This was invented by William Scherer, who constructed two bridges on this principle in Chicago. The construction and operation of this bridge will be

understood more easily from the illustration than from any printed description. The halves are heavily counterbalanced on the shore

Scherer Rolling Lift-Bridge, State Street, Chicago, Illinois. (Showing Swing-Bridge in the distance.)

ends, so that they can be elevated by a rolling movement, that is not only quick of operation but requires small power and leaves the

river entirely clear of obstructions. This type of bridge has another advantage in that it is impossible for a car or vehicle to run into the open draw, as the bridge itself forms a positive stop, as well as a conspicuous signal to any approaching train. Electric power is now being used to operate these rolling-lift bridges, and the ease with which they can be lifted or opened is shown by the fact that the large bridge at Boston, having double-track spans, employs only a fifty horse-power motor for lifting each half, and the bridge can be opened or closed in thirty seconds. The Rush Street bridge in Chicago is opened forty times a day on an average,

Modern Steel Trestle Bridge, Japan.

using electric power that costs on an average sixty-seven cents per day.

One of the most singular bridges of the world is that known as the ferry-bridge at Bizerta, on the Mediterranean. This bridge has steel towers and a crossway that would serve as ordinary roadway were it not that it has no approaches, and is 148 feet above the water. The method of crossing is by a suspended car that constitutes a ferry. This being hung by steel ropes, attached to a wheeled carrier on the crossway, is run over the channel, skimming about a foot above the water. A fifteen-horse-power steam-engine, having a drum and a steel cable, draws the carriage back and forth across

the water, thus operating the ferry. This structure was completed in 1898 at a cost of $112,000. There is a somewhat similar ferry bridge at Bilboa, Spain.

American bridges are built almost wholly with a view to utility; only in Europe does one find bridges where much expense is undertaken to add beauty to the structure. One of the most artistic bridges in the world is that at Bonn across the Rhine. This bridge is of steel, and has towers set well out into the river, which towers are built in imitation of mediæval castles. The shore towers are also suggestive of ancient castles, and the approaches are in keeping with this idea. The main span of this bridge is 616½ feet long. the supporting truss being built in the form of an arch from which the deck or roadway is supported, forming a bow-string. On the

Willis Avenue Bridge, New York.

side spans the arch-trusses are below the roadway. As this bridge constitutes a sort of gateway to the historic section of the Rhine, its construction is most creditable to the city of Bonn, which paid the bill, and to the designer, Professor Krohn, who was assisted by Professor Schill.

Another beautiful bridge designed by the same men is that at Düsseldorf on the Rhine; this has massive portals in the Renaissance style of architecture. In connection with these bridges should be mentioned the bridge over the Aare at Berne, Switzerland. The banks at this point are quite high, so that the roadway runs on a level with them about one hundred feet above the water. The main span is 376½ feet, which is covered by a graceful steel arch, rising

from tapering stone towers. The trusses and railings are most ornamental, as well as the tops of the towers.

A typical bridge of the American type, constructed with a swing-draw, is shown in the accompanying picture of the Willis Avenue bridge, over the Harlem River at New York. The crossed braces afford great strength, the top and bottom chords being of built-up box sections, curved to secure a graceful effect. The swinging span of this bridge is 310 feet long, and affords a roadway forty-two feet wide.

Pontoon bridges are not common, but there is one at Calcutta, built of iron girders, that is 1530 feet long, and rests on twenty-eight pontoons; another at Prairie du Chien, Wisconsin, across the Mississippi, having a total length of 7000 feet, part of which rests on an island and part on the pontoons. The Chilean State Railway bridge, over the Mallen River, is one of the highest in the world, its deck being 333 feet above the river. There are five spans, and the total length is 1419 feet.

THE MACHINERY OF AMUSEMENT

THE production of mechanisms for the amusement of the public is not usually classed as an industry, yet it is an important one in its way, providing occupations for genius of varied kinds. From a "loop-the-loop" contrivance to an automatic chess-player is a considerable distance, hence the invention and construction of the mechanisms that we are now classing together are wrought out by men who are usually far removed from each other, and have little knowledge of each other's methods.

Courtesy Munn & Company.

The Droz Automatons.

Away back in the eighteenth century there was a craze for puppets or marionettes, and Jacquet Droz and his son of the same name constructed a number of these human automatons, which they termed androids, and which were exhibited in Paris, London, and other cities, creating general astonishment, being the most perfect of their time. One was known as the "writer," another as the "draughtsman," and a third as the "musician." The "writer" was the figure of a child, of perhaps six years, sitting on a little stool at a desk. She handled a quill pen like a human being, taking it

in the right hand, dipping it in the ink, squirting out the superfluous ink, moving the head and eyes slightly while writing, and producing short sentences with carefully shaded down-strokes, in the fashion then prevailing. Any short sentence could be written, but the man in charge had to set the mechanism for the sentence in advance, this work occupying about two hours.

The operating mechanism was inside, the power being furnished by a long string, wound up on a drum. The motions of the pen were controlled by 120 little disk-cams, each designed to form a particular letter when brought into play. These cams being set in the proper order and position would produce the appropriate sentence.

The "draughtsman" also worked with a pen, and drew one of a certain series of pictures. When exhibited before Louis XV. he drew the king's portrait, which so pleased his majesty that Jacquet Droz was decorated with an order. Before George III. the "draughtsman" sketched both the king and Queen Charlotte. While making the drawings the figure would pause at times, throw back his head as if studying the work, blow away real or imaginary dust from the picture, and generally conduct himself in a life-like manner.

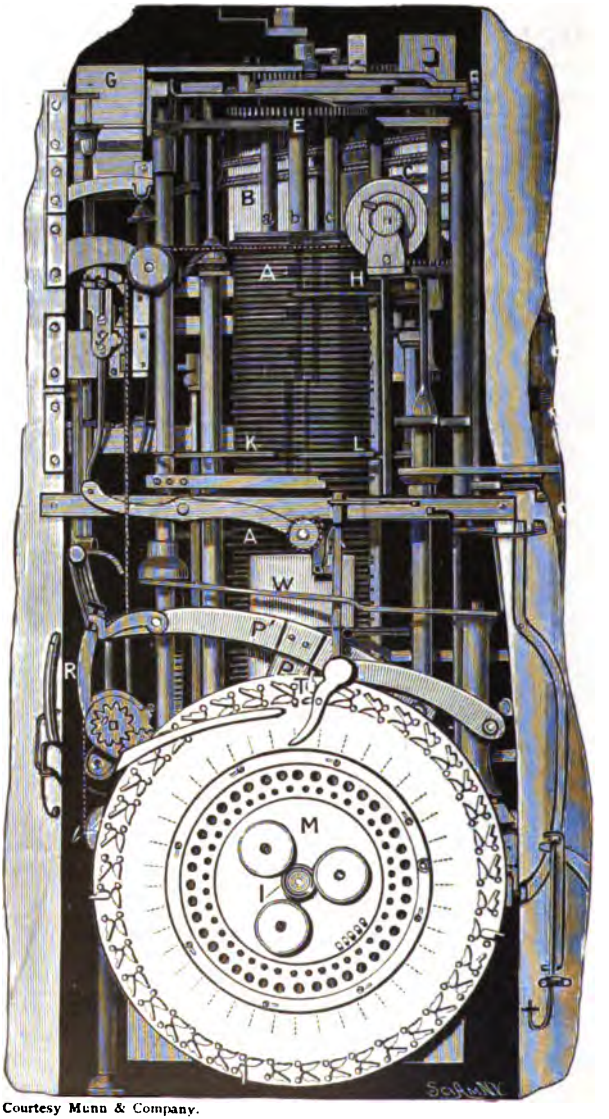
The "musician" was an android having the figure of a young girl of perhaps thirteen, seated at the clavinos, the equivalent of the modern piano. She fingered the keys by pressure, as would a person, and made a number of appropriate and graceful gestures. Her mechanism could be adjusted to play several different tunes.

These remarkable puppet mechanisms are still in existence, being in the custody of Henri Martin, of Dresden, Germany. They have never been surpassed by anything of their kind.

About forty years ago P. T. Barnum exhibited through the United States a talking-machine that was built at a cost of $20,000, and which, by blowing air through variously adjusted passages, formed words and sentences that came from the head of a figure after the manner of the human voice. As a piece of mechanism this was marvellous, though eclipsed by Edison's phonograph, which talks better by much simpler means, and the talking casts, described in the chapter "The Wonderful Instruments of Science."

The automaton chess-player has delighted thousands at the Éden Musée in New York and elsewhere. A cross-legged Turk sitting at a chess-board is the usual figure. He will play chess or checkers with all comers for a small sum, handling the pieces correctly, and winning the games with painful regularity. A window

in the chest of the figure is opened to convince the sceptical that no person is concealed inside, yet there is a man inside, a player of skill, who swings the arm that moves the pieces. The mechanism



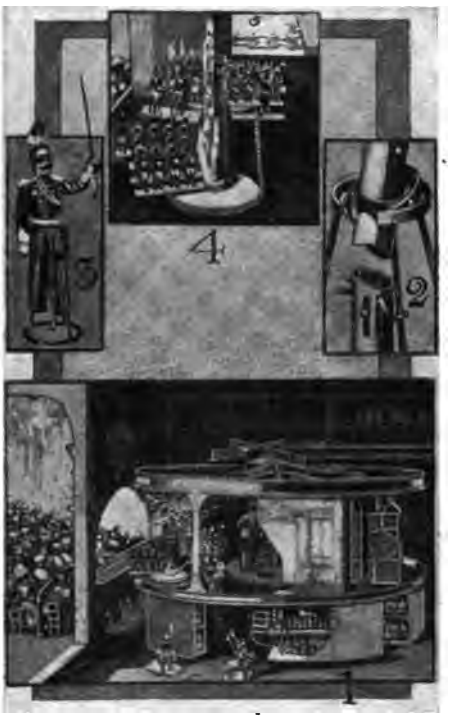
Courtesy Munn & Company.

Mechanism of the "Writer."

was patented many years ago, and the curious by looking up the record can see just how it works. The man must be slight, and he sits down low in the figure, looking out through the window in the

chest. When the attendant prepares to open the window so that the bystanders may look right through the figure, the player drops down into the base out of sight.

The acme of puppetry was attained at the Paris Exposition of 1900, where the Guillaume puppet theatre was a star attraction. Upon a miniature stage a number of entertainments were given, all the characters being puppets or marionettes, of which there were



The Puppet Theatre.

1, The revolving stage, mounted on a drum; 2, mode of suspending a puppet; 3, puppet, dotted lines showing interior mechanism; 4, automatic marching of soldiers; 5, showing the carrying chain and its fastening.

more than four thousand used in the different scenes represented. Companies of soldiers were marched across the stage and made to go through a variety of evolutions, and troops of cavalry galloped back and forth with a naturalness of motion that was the wonder of wonders to onlookers. Spectacular scenes from well-known plays were given, and humorous and clownish performances—in all a variety creditable to any theatre. Four set scenes were used, the time of scene-shifting being saved by mounting them in the four

quarters of an upright drum. (See illustration.) At the end of an act the drum was given a turn, and an entire new scene was ready.

The puppets for a particular piece were set on shelves below the stage, and several attendants standing below, out of sight of the spectators, would guide the puppets to their positions on the stage by means of rods extending below their legs, so that they appeared to walk on of their own volition. The motions of a number of puppets could be controlled from below by one man operating a set of keys, and at the same time he could speak their parts after the fashion of a ventriloquist. The stage had all sorts of modern accessories, so that the performances were highly realistic.

The mechanism of the stage possesses nothing more interesting than the contrivances used to deceive the public in feats of prestidigitation or legerdemain. The old sphinx trick was one of the best of these in its day, but is now so well known that it has ceased to be presented. A live human head was shown on a plate set on top in the centre of a little three-legged table. As the spectators could see under the table and all around it, there was no accounting for the activity of the head until the means were made known. The stage was draped all in one color, as green; the table was set with one of its three legs directly towards the audience, and underneath it a man sat comfortably on a stool, hidden from view by two mirrors set between the legs. These mirrors reflected the green surroundings, and the onlookers thought they saw through under the table to the green hangings in the rear. The plate and table, of course, had holes for the reception of the man's neck.

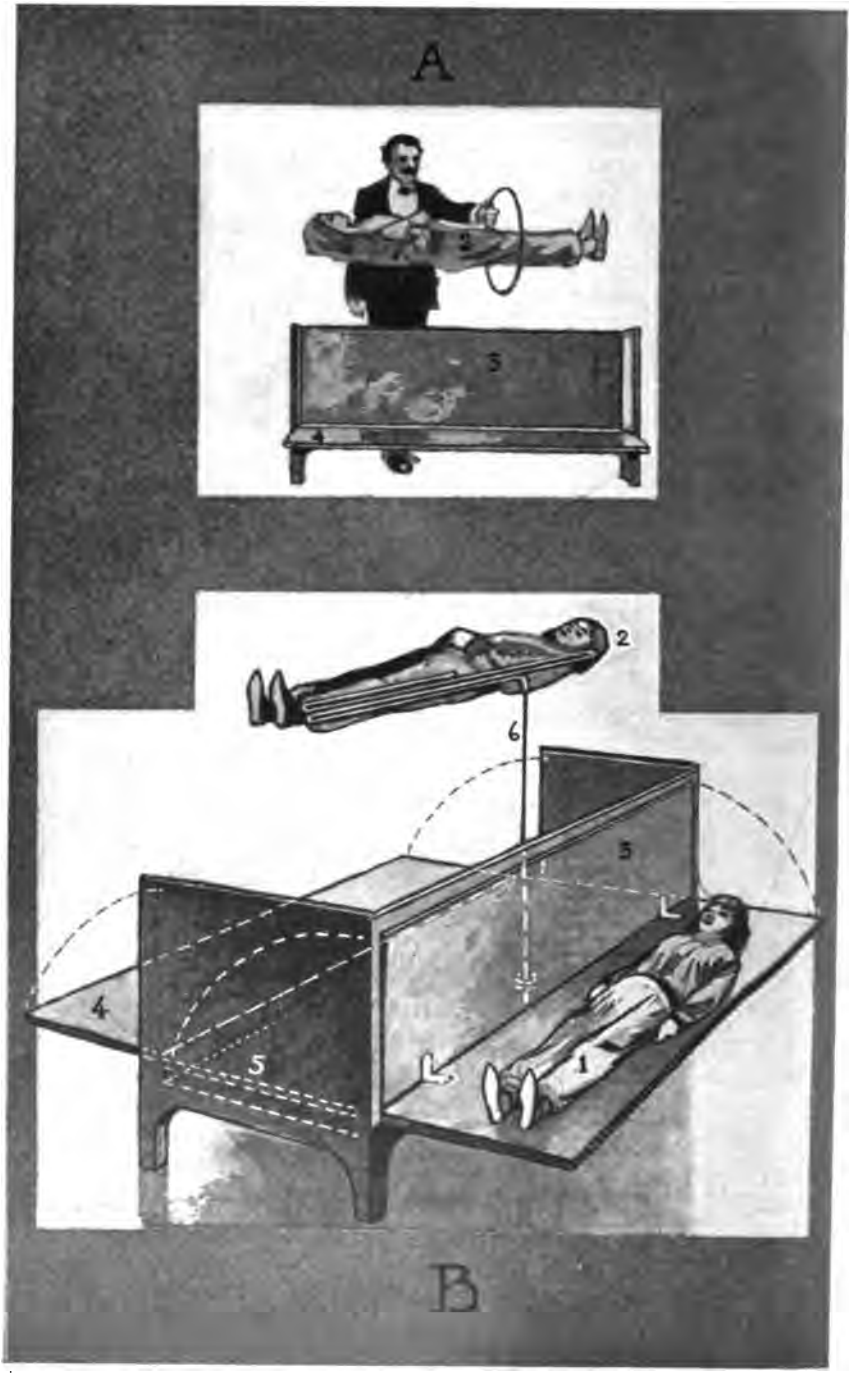
Quite as simple, but less known now, because older, was the ghost trick, played successfully in Paris about a century ago by Houdin. The audience saw a cavalier walking about in a troubled way, and shortly a typical ethereal ghost appeared and began to mock him. The cavalier drew his sword and rushed at the ghost, but walked right through him. Again and again he endeavored to slay the ghostly visitant, with the same result, and finally the cavalier withdrew, seemingly tired out and frightened, while the ghost held the stage at the curtain-fall. This effect was produced by placing a very large plate of clear glass nearly upright at the front of the stage. Beneath the real stage was a duplicate stage out of sight of the audience. On this walked the ghost, his figure illumined by a following light. The glass caught the reflection of the illumined ghost and made him appear to the audience as if treading the boards of the real stage. The cavalier walked about on the

real stage back of the glass, and when he appeared to make a pass of his sword through the ghost, it really only passed back of the reflection of the ghost. Both stages were covered with elaborate chalk-marks, so that the cavalier and ghost should march about in the proper positions in relation to each other, for neither could see the other, the audience being the only ones in a position to combine the two figures. The principle involved in this trick has been used in a variety of ways to produce illusions, and is used to this day.

The floating lady is a trick that has mystified thousands, and that never fails to please spectators. It has been performed in two ways to the writer's knowledge, and perhaps in more. In the first way, the lady, dressed usually as a fairy, steps up on a little platform, on top of a low stool, and with either elbow resting on an upright bar or stick, placed under as a prop. The stage magician comes along and kicks away the stool, when the lady appears to support herself by her elbows on the ends of the sticks, with her feet perhaps eight inches above the ground. The magician makes a few passes, and then takes away one of the sticks. This fails to upset the lady, who calmly rests on one elbow only, touching nothing else. The magician about this time kindly mesmerizes her, under pretence of relieving the tension on her muscles, or for some other excuse, and raises her to a horizontal position, where she stays and floats, connected with the stage floor only by the one upright stick to her outstretched elbow. There, in apparent contradiction to the laws of gravitation, the lady is posed in various positions, and finally returned to terra firma by a reverse of the actions by which she was elevated.

In performing the above trick, one of the sticks that supports the lady's elbow is really a steel tube. Inside the lady's dress is a steel frame-work that is connected up one arm as far as the elbow. When her elbow rests on the tube, it is bolted firmly to its top, while the lower end of the tube sinks a short distance into an invisible hole in the platform. Thus the tube and the steel frame-work do the supporting when the stool and the other stick are taken away.

The second method of exhibiting the floating lady is operated on a newer and better principle, as illustrated in the accompanying drawings. The lady is first put to sleep in a chair, which is supposed to be balanced, but which is held securely by a steel rod run through the stage floor and up one leg. She is next laid on a couch, which opens towards the spectators, so that they can see under it and into it. The live lady is placed on the couch at the



The Floating Lady Trick.

A, As viewed by the spectators; B, as it really is. 1, The live woman; 2, the rubber doll; 3, double false back; 4, front, "let down;" 5, false bottom; 6, steel supporting rod, looped to sustain the doll.

front side F, while in the rear at A, out of sight, is a dummy that looks just like her, but is really an India rubber doll, weighing perhaps ten pounds. The magician closes up the lady in the casket and steps to the rear, where he appears to pick the lady out of the casket and leave her in mid-air, while he passes hoops around her to prove that there are no supports. What he really does is to pick up the doll that resembles the lady, and as he picks up the doll he also pulls up a black wire rod, smaller than it appears in the picture, and which is invisible to the spectators because it is against the background of his black clothes. Having thoroughly misled the onlookers, he restores the doll to the hidden shelf, lets out the lady, and awakens her to receive the plaudits of the multitude.

The disappearing lady is an equally clever trick. The stage magician announces that the lady will disappear from the stage in full sight of the audience, and that none may think she goes down through the floor, he spreads a newspaper on the stage, and on this a chair. Then the lady is seated on the chair, put to sleep in the most approved mesmeric style, and a large sheet thrown over her, entirely concealing her from view. The magician makes sundry passes, and utters an incantation, then suddenly removes the sheet and throws it on the stage floor. There are the chair and the newspaper but no lady. It looks impossible, but the explanation is simplicity itself. There is a trap in the stage floor; the newspaper is not what it seems, but a rubber blanket, on which a newspaper is pasted. The blanket and paper are slit through in the form of an X, but a piece of paper pasted on the back closes the opening, so that it looks like an unbroken newspaper. The chair is set carefully over the X opening, and this over the trap-door. When the sheet is over the girl and all ready for her to disappear, she doubles up and drops through the hinged bottom of the chair, through the X in the rubber blanket, and through the trap-door into a net below the stage.

Of course, the girl must be slight and something of a contortionist, as her feet and head go through the chair together. The sheet is supported temporarily after the girl drops out by light wires that fold up with it, so that wires and sheet can be flung together flat on the stage. The hinged bottom of the chair returns to place by means of a spring, and when the trap-door is closed, the rubber-backed newspaper appears as intact as ever.

Illusions based on the principles here described are exhibited every day in theatres. When a portion of the public becomes familiar with them in one form, they are changed as far as the effects are

concerned, though the basic principles are the same. People who read descriptions mostly half-understand them and afterwards forget; then, as Barnum said, the public likes to be fooled.

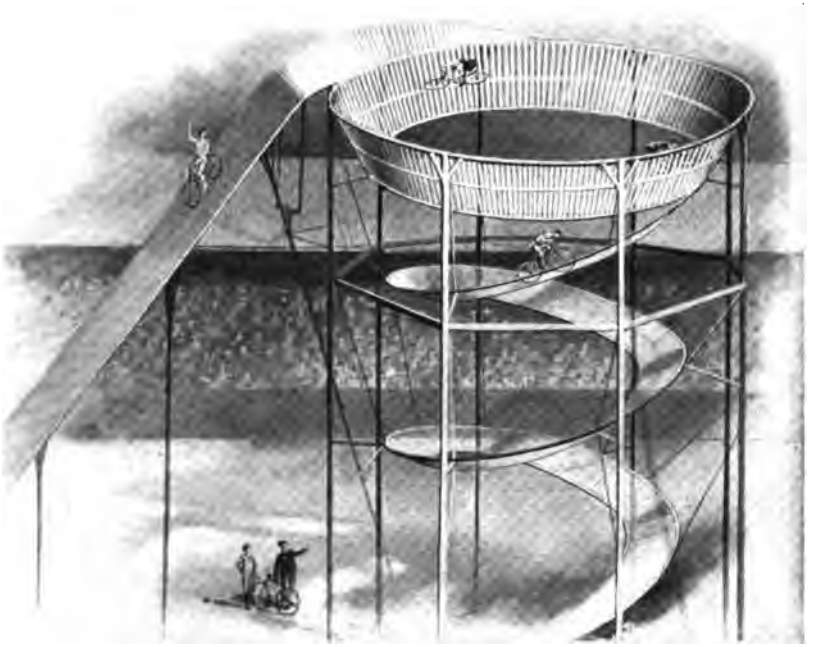
The mechanism of a good theatre stage is quite elaborate. There are trap-doors in the floor, and slides for the scenes, and

The Disappearing Lady.

electric lights at various points, all arranged to be controlled from one station. Then there is the thunder-making machine, that rattles sheet-iron; the tumble-box full of old iron and crockery, to imitate the effect of throwing the villain downstairs or out of the window; the snowing-machine, that drops bits of small paper over the poor, begging blind girl (usually dressed in rags and high-

heeled slippers). Every spectacular play requires a lot of special machinery, as for operating a rocking raft, a falling building, or something of the sort. These are designed by skilful mechanics, who make a business of that sort, and are prepared to produce anything a playwright desires.

The Covent Garden Opera House is one of the best equipped theatres in England. During a recent summer its stage was entirely torn out and reconstructed with modern bridge machinery. These



Courtesy Scientific American.

The Circle of Death.

bridges or sections of the stage are six in number, and when set in simple position constitute the usual stage floor as inclined towards the audience. The front section is stationary, but each of the other sections is made in the form of a trussed-steel bridge, and is movable in any direction. These sections or bridges are eight feet wide and forty feet in length, and can be raised nine feet above the stage level or dropped eight feet below it. They are counterbalanced like elevators, and each is calculated to carry at least two tons of live weight. This arrangement of the stage floor makes it easy to produce all sorts of scenic effects in quick time, and without any of

the danger that comes to the actors where light and quickly built wooden scaffolding is employed for stage structures.

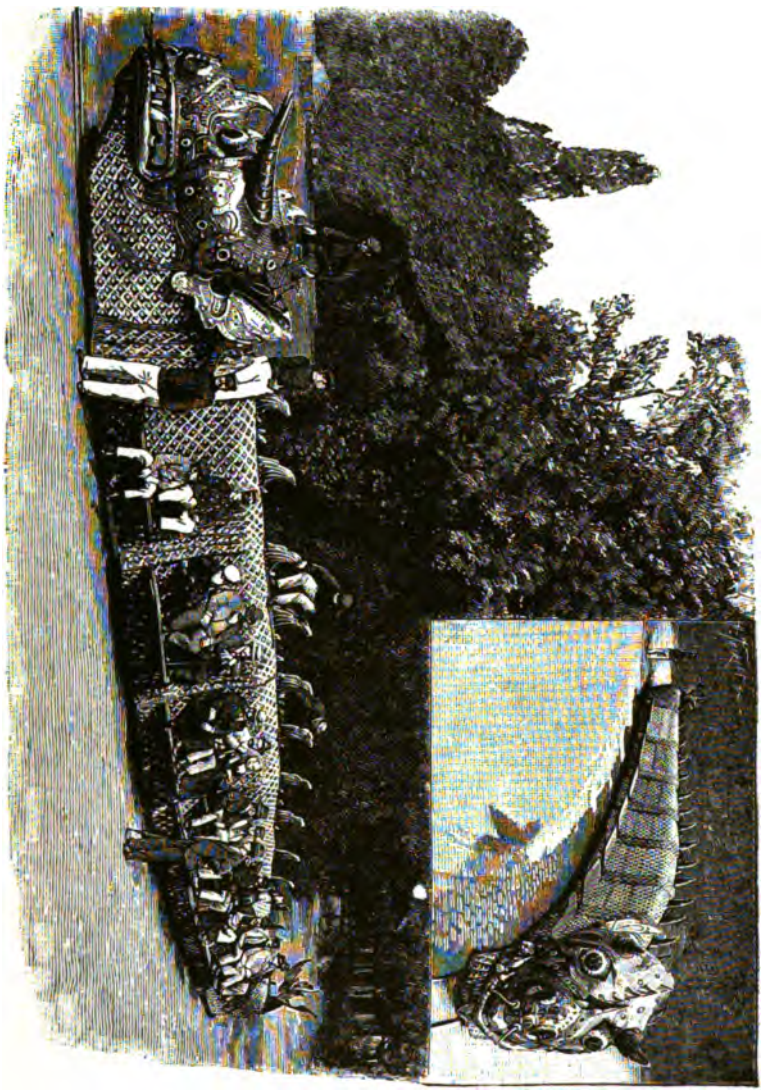
The loop-the-loop exhibit is based on a mechanical toy, familiar to every engineer, and might have been brought out years earlier had anybody supposed that people would risk their necks for the fun of turning such somersaults. Various "improvements" on the loop-the-loop have been devised, with the object of making the looping more dangerous and spectacular One of these is the "circle of death" here illustrated. The trick of shooting a woman out of a cannon is not what it appears, as the woman is really thrown up into the net by a powerful spring mechanism that is certain to throw her the same distance every time. The explosion of a little gunpowder at the instant of releasing the spring, gives the effect of firing her out of the cannon, which would be highly dangerous if not certainly disastrous.

A very simple but amusing recreation is furnished frequenters of the Jardin d'Acclimatation, in Paris, where a dragon-like sea-serpent wanders through the grounds, giving a ride for a small sum to those who choose to seat themselves on his sides. As shown in the illustrations, this is simply a little railway train, operated by a storage battery, and having an engineer inside the head, peeping out to see that he does not run over people.

The kinetoscopic pictures, cinematographic or moving pictures, as they are variously called, afford almost infinite opportunity for the display of tricks that could not possibly be rendered as they appear. In order to understand how these trick pictures are produced, the reader should first grasp the method by which the moving pictures are made. Let us suppose that a stage dance is to be reproduced in moving pictures. A photographic machine is set up during the dance, which takes instantaneous pictures at the rate of forty-six a second on a strip of sensitized photographic film, perhaps half an inch wide and half a mile long. To do this the film has to be stopped and started forty-six times in the second—a process far too intricate for the eye to follow; in fact, the speed of forty-six a second was chosen because it was found that the human eye could not detect these small fractions of change, owing to what is termed the persistence of vision. The film being made, it can then be run through an exhibiting-machine, which is somewhat like the old-fashioned magic lantern, with a device for stopping and starting the pictures every forty-sixth of a second. These pictures being thrown on a screen and enlarged give the effect as if the real scene were under view, except that the colors are want-

ing, and that there is a slight tremor owing to the vibration of the film in being stopped and started at so rapid a rate.

These being the conditions, it is easy to see that one has only to cut out a series of pictures from the film to secure some omission

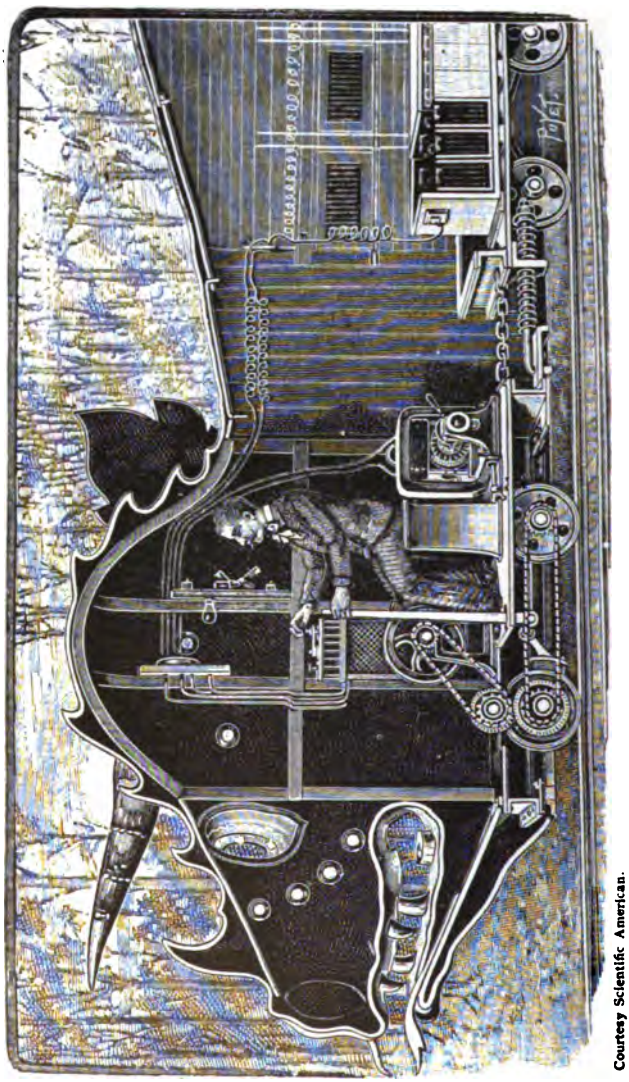


Courtesy Scientific American.

The "Sea Serpent" of the Jardin d'Acclimatation.

from what really took place in the scene photographed, and the tricksters take advantage of this to secure novel results. Take the human incubator trick, for instance. A man appears standing be-

fore a table, bearing a plate and half a dozen eggs. He picks up an egg, breaks it up in the air, and allows the contents to fall to the plate; just as they strike the plate they are transformed into a live



Interior of the "Sea Serpent."

Courtesy Scientific American.

chicken, which toddles off. This is repeated with all the eggs until there are six chicks running about the table. Then the man holds the last shell above the plate, and a chick runs into it, and the egg is closed and put back on the plate, and so on until all the chicks

are back in their shells, and there is nothing left but a bowing man and six eggs on the plate.

In producing this series of trick pictures the man while being photographed stands before the plate of eggs, breaks one into the plate, then picks a little chicken out of a basket near by, and sets it on the plate, and it naturally toddles off. As he breaks each egg, he picks up a chick. A series of pictures having been produced by this performance, it is only necessary to cut out those pictures that show the man reaching after the chicks and putting them on the plate. The strip of pictures for exhibition purposes is pasted together with these omissions, and the spectators see the scene as first described. The putting of the chicks back into the eggs is accomplished by running the strip of photograpic films backwards through the exhibiting-machine.

"Dr. Sawbone's Busy Day" is another product of the trick-picturist, if I may be allowed to coin a term. A man with two wooden legs enters the doctor's office, the doctor unscrews them, takes a couple of good legs out of a closet, and puts them on the cripple, who dances in glee; but his dance is short, for the doctor grabs him, throws him over a table, and with a meat-saw neatly severs his head from his body, throws the head in the corner, and takes another head from a closet and substitutes it. The cripple-that-was gets up, shakes himself, looks in the glass, is staggered at his appearance, and makes off.

The solution of this is that in taking the photograph at the time the legs are applied to the cripple, the real cripple walks out and a man with two good legs, but resembling him, takes his place. Just before the head is sawed off, a dummy is substituted for the man, and after the head is on again, a man with a similar head takes the place of the dummy. When the parts of the string of pictures that give away the trick are cut out, it is ready for production.

A more exciting trick-picture is that of the tramp who settles himself on a railway track, drinks till he is dead drunk, and lies on the track, until an express comes along and knocks him into fragments. This never fails to send a thrill of horror through the spectators, which turns into a laugh later when the men who are carrying away the remains on a stretcher, stumble and fall, while the "remains" jump up and run away laughing.

Of course, this series of pictures is produced in the same way as the previous, the man representing the drunken tramp getting up and putting a dummy in his place before the train comes along.

and taking the place of the mangled dummy later at the revivification.

One of the latest and most interesting of moving-picture exhibits does not owe its existence to any trick, but to the skill of photographers in securing good photographs of microscopic subjects, that will bear magnifying and displaying on a screen. These are called moving microphotographs, and are used to exhibit the lives of bees in hives; the conditions within a drop of river-water, showing its flora; the circulation of blood in a frog's foot; the mites in a cheese, and the like.

Much more might be written about the machinery of amusement, but this seems enough to afford an insight behind the scenes, and for a wider knowledge of the subject the reader is referred to the mechanicians of the stage.

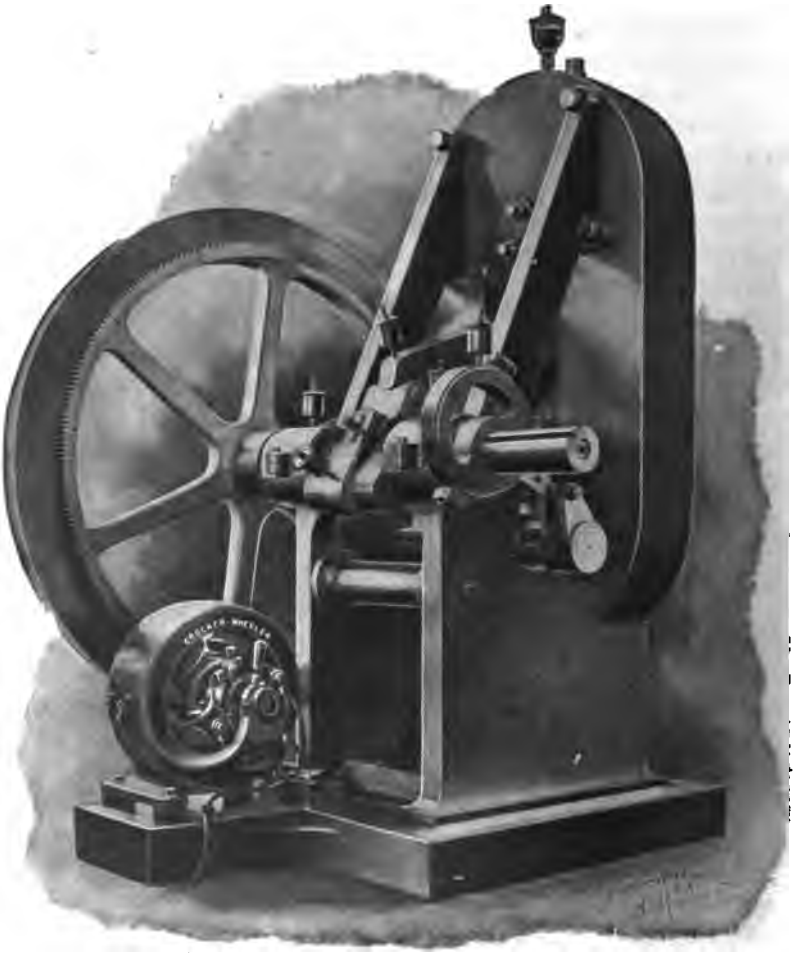
HOW MONEY IS MANUFACTURED

THE making of money by the governments of the globe constitutes no inconsiderable industry, employing many highly skilled men. The manufacture by private individuals—in other words, counterfeiting—also requires skill in a way, and keeps busy a portion of the Secret Service in discouraging the practice. United States coin is minted principally in Philadelphia, what is called the new Mint being located on Spring Garden Street. The gold and silver are obtained as bullion—that is, in bar-form—and have first to be assayed, either at the mine or one of the assaying offices, of which there are several. Its value being thus accurately determined, it requires to be alloyed, or mixed with ten per cent. of another metal, to give the coin wearing quality. Copper is the metal employed for this purpose, and after the gold and silver are properly mixed by melting together in a large black-lead crucible, they are poured into moulds to form ingots. These vary in size according to the size of coin to be made therefrom, those for double eagles ($20 pieces) weighing eighty ounces, and being over a foot in length, and of the width of the coin, and half an inch thick.

The ingots are rolled to harden and elongate the metal, and before the final rolling they require to be annealed, which is done by placing them in a furnace, where they are subjected to a heat of 1500° F. for an hour and a half, and then cooled in water. After going through the finishing-rolls three or four times, they are again annealed and cut in two. At this stage the metal is reduced to the thickness of the coin to be made, and it is taken to a machine that cuts or stamps out blank disks of the size of the finished coin. It is necessary to weigh these blanks, to make sure that no coins are turned out over or under weight. Those that are incorrect go back to be melted over, while those of correct weight go to the upsetting-machine for milling the edge. This machine, working on half-dollars, will produce 575 a minute, and other sizes in proportion. A man feeds the coins down a tube, and they are worked up against a disk that rotates them against the milling surface.

Another annealing follows, and then the blanks are cleaned in a solution of sulphuric acid and water that brightens them. After being rinsed in hot water and dried in sawdust, they are ready for the stamping or coining press. This machine has dies, in which

are engraved, in reverse, the opposite faces of the coin. The blank being inserted and subjected to a hydraulic pressure of many tons, comes out finished. The method of engraving dies is described in another chapter. The stamping-press for ten-dollar gold pieces



A Mint Stamping-Press. (Showing Mechanism and Motor.)

exerts a pressure of 120 tons, and will turn out about a hundred coins a minute. The double-eagle requires a pressure of 175 tons. One reason why counterfeiters are seldom able to make as good coins as the government is that they do not have as powerful stamping-presses, being obliged to depend on light machines, making up for the lack of pressure by a longer dwell on the blank.

After completion, the coins require to be counted and packed away. The more valuable coins are counted by handling one at a time, but the cents are thrown into a tray that has 1000 depressions. The counter brushes the cents around until he sees that every depression is filled, when he knows that he has just $10 worth of pennies. The government a few years since ceased buying up old copper cents, and now makes a considerable profit on their manufacture.

Annealing Furnaces, Philadelphia Mint.

The Philadelphia Mint employs the fuel-gas system of the American Gas Furnace Company. It was found that fuel gas involved a saving in the melting, because of the absence of ashes that formerly required to be saved and refined to recover valuable metal, this involving heavy expense. The temperature obtained with the fuel gas is also found to be more uniform than that where coal is burned. This gas is made automatically from naphtha, the gas-making plant requiring but little attention. The gas is distributed through all the departments of the Mint in pipes, just as city gas is distributed, but is purer and more effective than the latter, and is carried at a higher pressure. The annealing furnaces are shown in

accompanying illustration. In the view of the melting-room on page 447 are strips of silver that have been rolled down from ingots.

The Mint is frequently called upon to make assays for determining the amount of gold in bullion. A simple method of assaying is by cupellation, in which the metal, which may be an alloy of gold and lead, is placed in a porous cup called a cupel, and heated in a furnace until the lead is absorbed by the cupel, and only the gold and silver remain. See following page.

The United States Mints have coined nearly $2,500,000,000 of gold money since their establishment in 1792.

Gas-Making Plant of American Gas-Furnace Company, at Philadelphia Mint.

In 1870 the output of silver in the United States amounted in coining value to $16,000,000. The production increased steadily, and in 1874, the year in which the trade dollar was floated, the production amounted to $35,750,000. The year 1878 saw the passage of the Bland bill by Congress (over the President's veto), and the output of silver coined amounted to $45,200,000. The record year for the production of silver was 1892, when the figures of the mints in the United States were over $82,000,000; since that date it has fluctuated in the sixties and seventies (coining value). Mexico's production was greater than ours in 1902 by a few million, but no other country approached us.

The United States was a large purchaser of silver for coining purposes from 1878 to 1893. Under the act of 1873, it purchased in two years over $7,000,000 worth of silver for coining; under the act of 1875 it purchased during three years over $37,000,000 worth; while under the Bland act of 1878 it purchased in a little over two years over $308,000,000 worth of silver! From July 14, 1890, to November 1, 1893, when the last purchase of silver was made for manufacturing dollars, $156,000,000 worth was purchased. The value stated in each case is the price paid for the silver bullion, and not the value as coin, which would be very much larger.

Cupelling.

The year 1853 saw the largest production of gold in the United States, the output of that year being 3,144,374 fine ounces of the value of $65,000,000. This record stood for a great many years, but was exceeded in 1899 and 1900. In 1902 our product swelled to 3,870,000 fine ounces, of the value of over $80,000,000. Even in this last year the mines of Australasia surpassed us by $1,500,000.

Of course, not all the gold goes into money, nor nearly all the silver, but a large part of these precious metals go to making money, which is the reason why the figures are introduced here. The total stock of money in the world, including gold, silver, and paper, is given in the following table covering the facts as far as obtainable up to 1903:

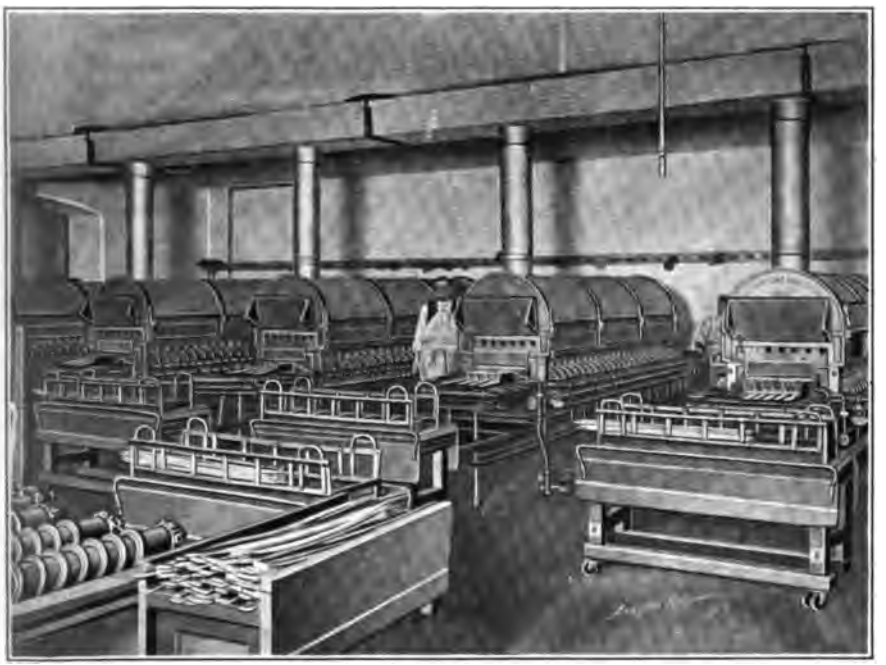
THE WORLD'S SUPPLY OF MONEY

Countries.	Stock of Gold.	Stock of Silver.	Uncovered Paper.	Per Capita.			
				Gold.	Silver.	Paper.	Total.
United States	$1,248,000,000	$673,300,000	$456,100,000	$15.64	$8.44	$5.71	$29.79
Austria-Hungary	283,000,000	81,100,000	46,600,000	6.01	1.72	.99	8.72
Belgium	16,000,000	25,600,000	108,300,000	2 39	3.82	16.16	22.37
British Empire:							
Australasia	128,600,000	6,100,000	. . . . .	23.38	1.11	. . . .	24.49
Canada	33,800,000	6,700,000	56,900,000	6.26	1.24	10.54	18.04
Cape Colony	37,500,000	1,000,000	. . . . .	15 62	.42	. . . .	16.04
Great Britain	548,100,000	116,800,000	117,900,000	13.18	2.80	2.83	18.81
India	63,200,000	515,800,000	32,400,000	.21	1.75	.11	2.07
South Africa	29,200,000	1,200,000	. . . . .	24.33	1.00	. . . .	25.33
Bulgaria	1,000,000	4,900,000	1,000,000	.27	.78	.27	1.32
Cuba	2,000,000	1,500,800	. . . . .	1.25	.94	. . . .	2.19
Denmark	15,500,000	5,900,000	7,800,000	5.96	2.27	3.00	11.23
Egypt	30,000,000	6,400,000	. . . . .	3.06	.65	. . . .	3 71
Finland	4,100,000	600,000	9,100,000	1.52	.22	3.37	5.11
France	947,700,000	419,800,000	158,200,000	24.36	10.79	4.07	39.22
Germany	763,500,000	207,500,000	184,100,000	13.54	3.68	3.26	20.48
Greece	200,000	11,500,000	48,700,000	.08	.63	20.29	21.00
Hayti	1,000,000	2,300,000	3.500,000	1.00	2.20	3.60	6.70
Italy	107,700,000	37,700,000	171,300.000	3.31	1.16	5.27	9.74
Japan	62,600,000	30,400,000	61,300,000	1.31	.64	1.29	3.24
Netherlands	21,300,000	56,600,000	20,800,000	4.02	10.68	3.92	18 62
Norway	8,200,000	3,500,000	7,900,000	3.73	1.59	3.59	8.91
Portugal	5,300,000	6,500,000	63,000,000	.98	1.20	11.67	13.85
Roumania	14,300,000	800,000	8,100,000	2.38	.13	1.35	3.86
Russia	746,200,000	104,600,000	. . . . .	5.70	.80	. . . .	6.50
Servia	1,900,000	1,700,000	4,300,000	.76	.68	1.72	3.16
South American States	77,600,000	20,200,000	1,082,700,000	2.00	.53	27.90	30.43
Spain	75,800,000	173,700,000	142,900,000	4.08	9 34	7.68	21.10
Sweden	17,800,000	7,000,000	29,000,000	3.42	1.35	5.58	10.35
Switzerland	29,900,000	10,700,000	20,700,000	9.06	3.24	6.27	18.57
Turkey	50,000,000	40,000,000	. . . . .	2.08	1.67	. . . .	3 75
Cen. Am. States	2,000,000	7,000,000	30,200,000	.48	1.66	7.19	9.33
China	. . . . .	750,000,000	. . . . .	. . . .	2.27	. . . .	2.27
Mexico	8,600,000	106,000,000	54,000,000	.63	7.79	3.97	12.39
Siam	1,000,000	193,000,000	2,600,000	.16	30.63	.41	31.20
Straits Settlements	. . . . .	242,000,000	4,100,000	. .	47.45	.80	48.25
Total	$5,382,600,000	$3,869,300,000	$2,933,500,000	$4.19	$3.00	$2.28	$9.47

The making of paper money requires even more skill than coining, in order that counterfeiting may be made nearly impossible. The United States currency is printed on a special paper containing bits of colored silk, and the law provides that such paper shall not be made by any other than the authorized mills working for the government. Since the making of paper requires an expensive plant, this has been found to put an effectual stop to the manufacture of similar paper, counterfeiters resorting to pen-drawing or the like to imitate the colored-silk threads.

The designing of bills is done by an artist specially trained for such work, who takes a canvas, perhaps two by four feet, on which he paints in black and white the picture portions for a bank-bill or other note. The lettering is usually painted in by another artist, who is skilled in that branch of the work. The design having been submitted to the proper authorities, and usually subjected to more

or less alteration, is next submitted to the engravers. I use the plural advisedly, because a number of engravers are usually employed to complete the work on a single note, each taking that portion of the engraving in which he is specially skilled. By operating in this manner, the men acquire such skill in their specialties that no one engraver could engrave a whole note, which other men skilled in bank-note engraving could not detect as the work of one hand. The lathe-work or machine-engraving of the intricate and beautiful patterns common to the back of United States notes, and



The Melting-Room, Philadelphia Mint.

also to the border and "counters," is done by a most expensive machine, whose value places it practically out of the reach of counterfeiters.

The reason why paper money is printed in different colors is to prevent imitation by photo-engraving. If the work were done in black ink a fairly good copy could be made by any competent photo-engraver. Such copies might deceive the ordinary public, though they would not deceive experts. However, the green and blue and red printings so commonly employed will not photograph so as to make a good printing-plate, and this cuts off the majority of attempts at counterfeiting from the photographic side.

The bank-notes are printed in sheets of four bills each, marked "A," "B," "C," and "D," and appropriately and consecutively numbered. They are distributed to the public mainly through the national banks, which turn into the treasury old and worn bills, receiving new ones in their stead.

The manufacture of money has a special interest for almost every one, because money represents everything that can be bought. Its production is safeguarded on every hand by law, and a consid-

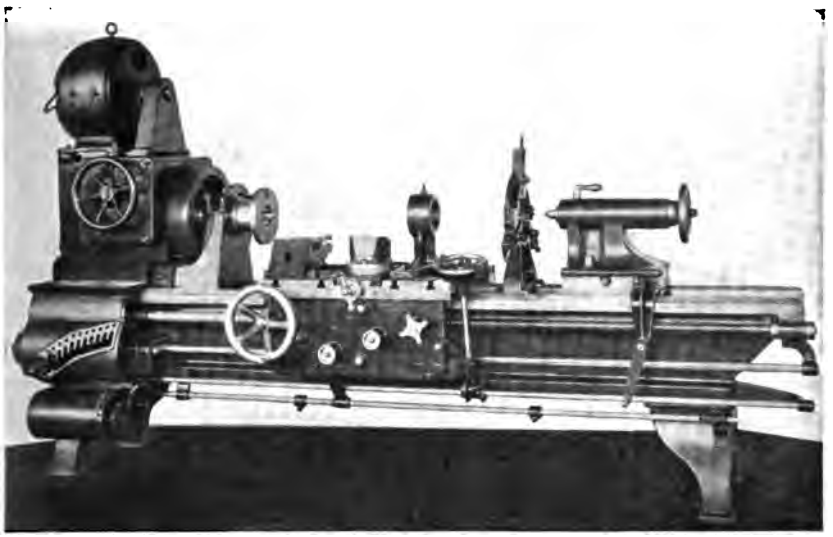
Courtesy Scientific American.

Cutting out Coin Blanks.

erable portion of the work of the government detectives in the United States, as well as in other countries, lies in following up and checking outbreaks of counterfeiting. Every man who goes into the business is sure to be run down and captured sooner or later, so that while the counterfeiter is perhaps the least criminal among criminals, in that he does not seek to do harm to any person in particular, yet he is perhaps the most certain to end his career with a long term of imprisonment.

MACHINE TOOLS AND MACHINE MAKING

THE primary tools that are used in the manufacture of other tools and machines are the lathe, the drill, and the planer. The lathe makes circular cuts, the work to be operated on being mounted between two centres, so that it will turn or rotate, and when a cutting tool is held against the work the latter can be turned down to a smaller size or shaped by circular cuts or chips, as they are technically termed. Cylinders, rings, cones, and similar articles all may



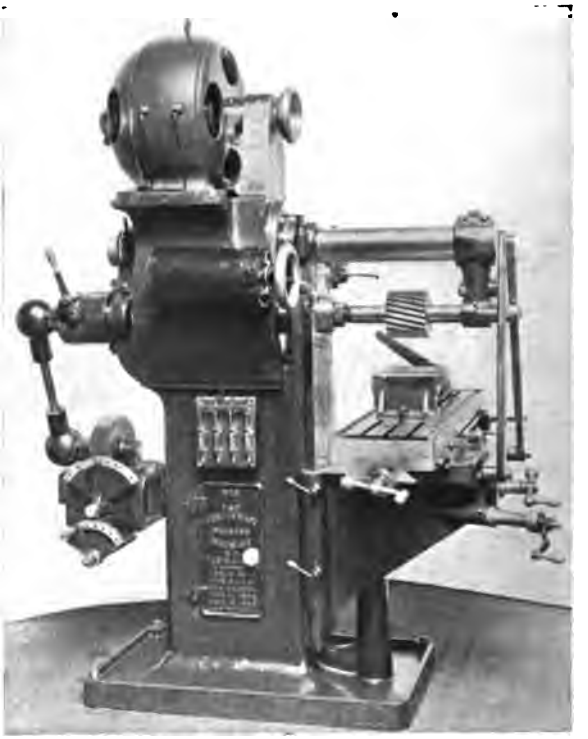
Courtesy Crocker-Wheeler Company.

A Modern Lathe, with Individual Electric Motor.

be turned in the lathe. The drill is a machine for cutting holes, as for the insertion of bolts, shafts, etc. The planer carries the work back and forth on a bed in such a manner that a cutting tool may be fixed, that is stationary, and produce a flat, smooth surface on the work that is moving.

During the eighteenth century there were very few such tools worthy of the name in use in the United States, as the laws of Great Britain expressly forbid the exporting of tools for working metals and manufacturing other tools. The English laws also prohibited mechanics and artificers from going out of Great Britain to practise their trades. These conditions made it very difficult to obtain

proper tools for machine-building on this side of the water. There are no reliable statistics as to the early tools, but it is stated on good authority that in 1838 there were but four planers in all the United States. However, with a planer, a lathe and a drill it is possible to build any number of other machines, and, having secured some kind of a start, our machinists went on and built more and better machines as the years rolled by. They supplemented the drill with the boring-mill, which turns out large hollows, as on the insides of



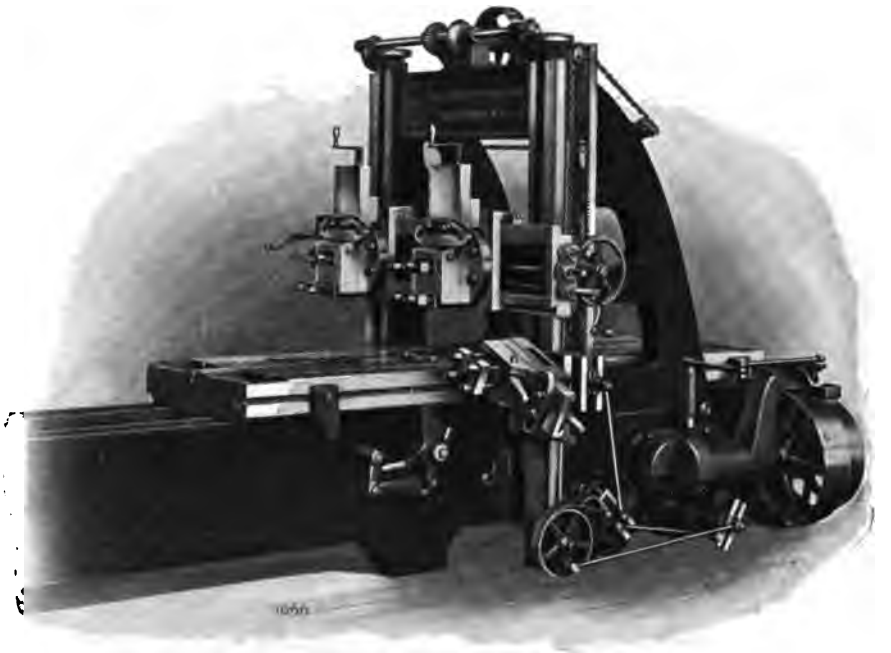
Cincinnati Milling-Machine, with the Crocker-Wheeler Motor.

cylinders. As a help to the work of the planer they provided the shaper, a small machine in which the cutting tool travels back and forth, while the work is stationary.

Screw-threads were first cut on the lathe, which was very slow and laborious; but in 1847 there was introduced the solid die of P. W. Gates, which had sectional threads for cutting, allowing the shavings to pass out between the sections. The principle is employed up to the present time, the screw-die being considerably improved by William Sellers in 1857. Before 1867 most gear-wheels

or cog-wheels were cast and used without machining, but in that year Sellers produced a gear-cutter, which cut or shaped the teeth accurately and scientifically. Now all gears are cut with automatic machines at very low cost, and there is no difficulty in regard to accurate cutting.

The milling-machine is a modern tool for doing a variety of fine and accurate cutting, by means of rotating cutters. Punching-machines are used to form holes by simply punching or forcing out a disk of metal with dies. Drilling-machines are made for a variety



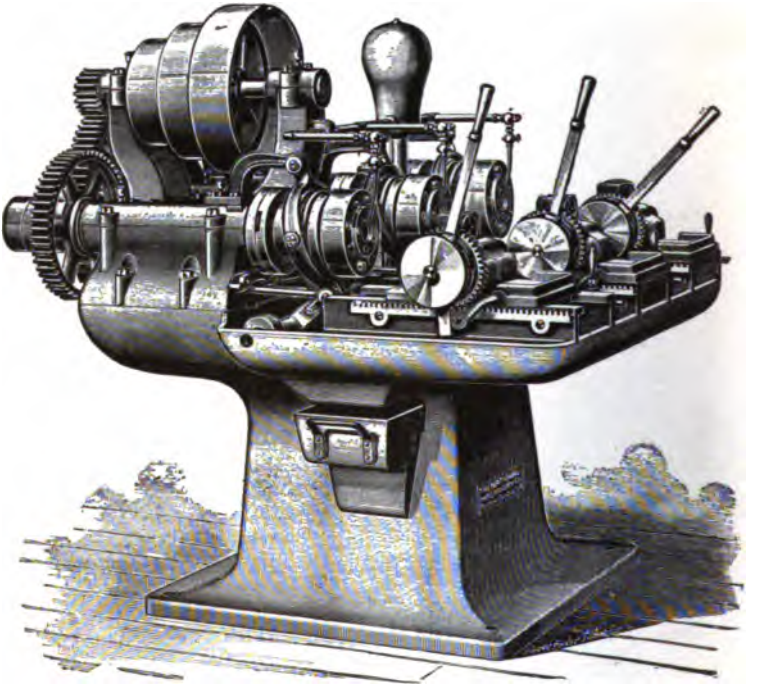
A Modern Planer.

of special work, having a series of drills that cut holes at the same time. Shearing-machines, operating on the principle of gigantic scissors, are made that will cut thick bars of steel. Rotary planers are manufactured having series of cutting tools all operating at the same time by rotation over the surface of the work.

The modern bolt-making machine is almost wholly automatic. An attendant thrusts in a bar that is square or hexagonal, and the machine grips it, squares off the projecting end, turns the body of the bolt, cuts the screw-thread, bevels the head, then cutting off the finished bolt, and moving the bar forward to make another bolt, proceeds with its work as long as there is any bar left to operate

on. This machine can be run by low-priced labor, and makes a better bolt than was formerly made by higher-priced labor by hand.

The above illustration shows the latest type of machine for threading bolts or rods. The dies automatically open and close when the required lengths of thread have been cut. The construction allows great ease of operation, and on account of the excellence of the threading-heads uniformity of production is produced. The machine is provided with lubricating pumps and chip- and oil-pans, making them thoroughly self-contained.



National Machinery Company's Triple-Bolt Cutter.

Not very many years ago new machines were developed on the "happy thought" principle, some inventor having an idea which he worked out as best he could. To-day the American method of manufacturing new and better machines is very much improved and systematized. The old-time inventor with a haphazard education has given way before the trained mechanical engineer, and when a new machine is wanted, or it is desired to improve an old machine, the problem is turned over to engineers experienced in that line of machinery. They are given the benefit of such ideas, patented principles, or "happy thoughts" as may be in the possession of the per-

sons desiring the machine produced, but they work out the machine largely on known scientific principles, and in this way, where there is sufficient money, will usually succeed in producing a commercial machine.

A trial machine having been completed and put in operation, defects and weaknesses are noted, after which a second machine is constructed, in which the endeavor is made to avoid the shortcomings of the first machine. Usually a third and sometimes several subsequent machines are built before the makers are satisfied that they have a commercial machine which can be operated successfully by an ordinary class of help.

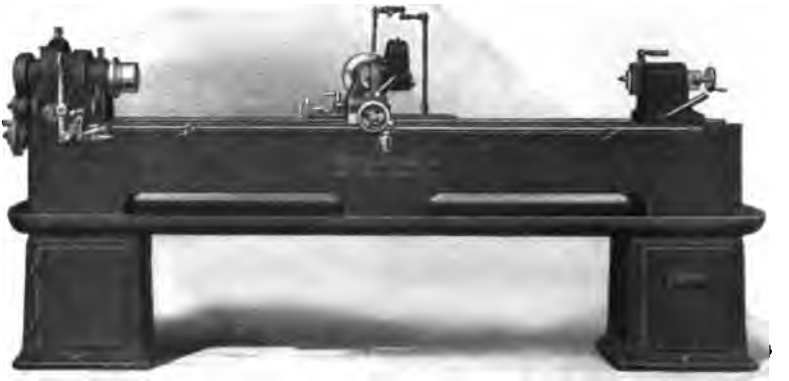
Courtesy of the Electrical World and Engineer.

An Electric Gantry Crane.

When the point of manufacturing a commercial machine is reached, a great many special tools and jigs are manufactured for the purpose of rendering the machines interchangeable, as well as for producing them at low cost. The larger the investment in special tools, the cheaper the machines can be made in quantities. The jig, which is the most common device used in making the parts of a machine so that they will duplicate, is simply a little iron framework for holding a casting that is to form a part of a machine. When the casting is tightly secured in its jig, it may be accurately drilled through certain holes exactly located in the sides of the jig

for that purpose. It may also be filed or machined or subjected to the action of any one of a variety of tools, each of which is limited or guided in its action by the form of the jig. When the casting is taken out of the jig, it is sure to be an exact duplicate of other castings that have been operated upon in the same manner in the same jig, and this is why when a part of a machine breaks the user can telegraph to the manufacturer and secure promptly a duplicate part that will exactly fit his machine.

This interchangeable system of machine manufacture originated in America, and is sometimes spoken of abroad as the American system. It is now followed by the leading manufacturers in the Old World. This system has the advantage not only of producing duplicate machines, but of doing the work with cheap labor.



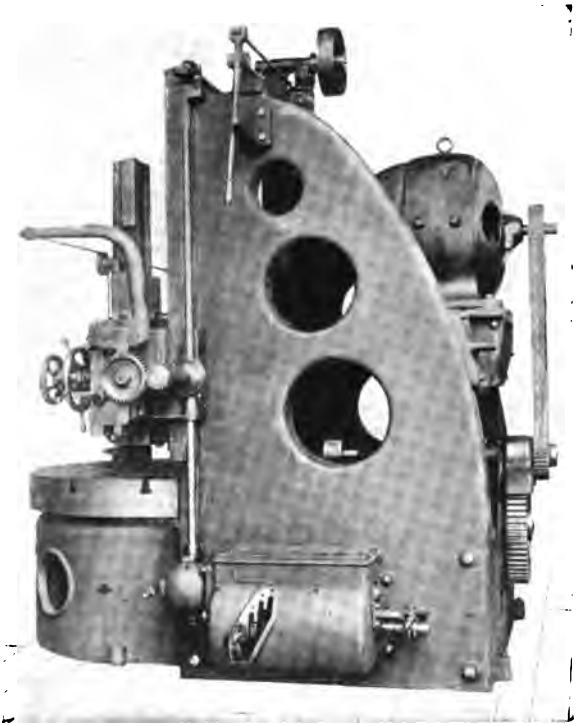
A Pratt & Whitney Lathe.

The brains and the high-priced labor are used in the production of the jigs, and when once these are correctly made any workman who can drill a hole or use a file or a planer can be trusted to make the parts by the jigs, with certainty that the work will be done correctly. In the manufacture of large parts that are too big to be placed in jigs, templets of thin sheet metal are clamped to the castings to be operated on, and the necessary holes are drilled through guide-holes in these templets, other operations being performed in a similar manner.

American manufacturers of high-grade tools produce them with extreme accuracy, measuring-tools having been made that will determine correctly differences as small as the twenty-thousandth of an inch. The tools of such concerns as William Sellers & Com-

pany, Pratt & Whitney Company, and Brown & Sharpe Company are sold all over the world, and bought by leading manufacturers of machinery everywhere.

During the past dozen years automatic lathes have been extended in use to much larger classes of work. The turret-lathe, which is a machine having a series of drills mounted on a revolving turret, has been applied to much larger and heavier work, and operated with what is known as the magazine-feed. This magazine is made



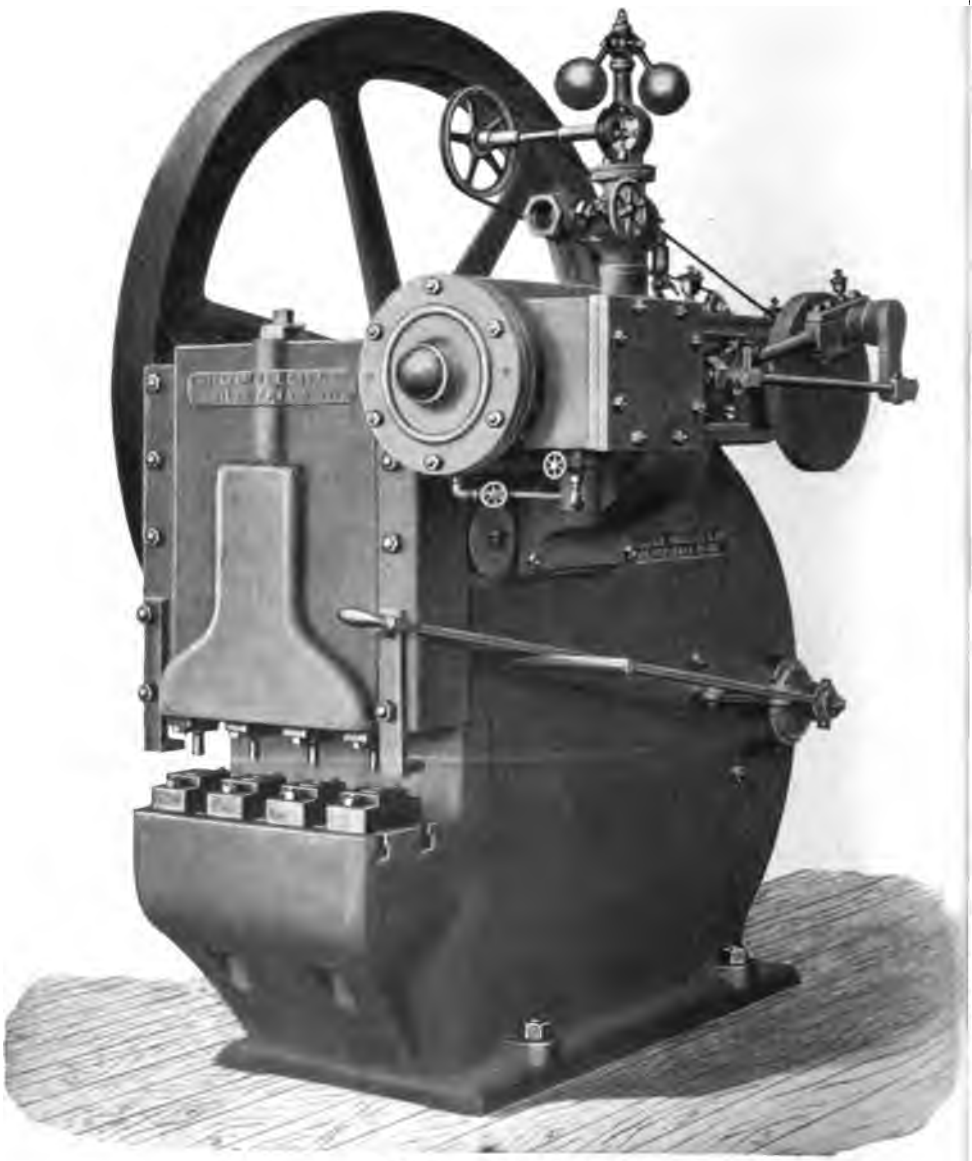
Courtesy Cro er-Wheeler Com an.

Boring-Machine, Electrically Equipped.

to contain a series of rough castings or drop-forgings, which are to be turned in the lathe; the feed mechanism pushes these parts along one at a time, while the lathe turns them up automatically, the attendant merely seeing that the magazine is supplied, that the cutting tools are in proper condition, and that the finished work is removed.

What is known as the oil-tube drill came into being about 1899, for use in drilling gun-barrels. This is a drilling-tool having a small channel for leading the lubricating oil near to its point, so that it

may be kept oiled during its work, without the constant use of an oil-can by the attendant. It is now used in a great variety of drilling-machines with a considerable saving of labor.

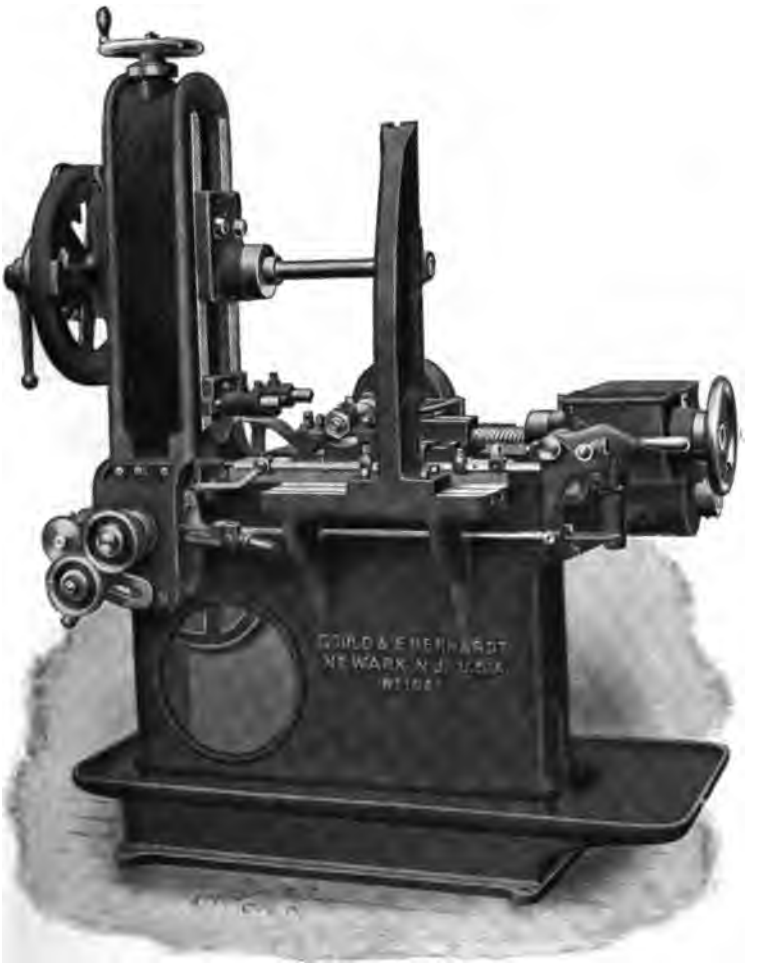


A Sellers Punching-Machine.

Among the pneumatic tools which have come into such extended use during recent years the pneumatic hammer is a con-

spicuous success. It was originally devised as a substitute for the hand hammer and chisel, and has become indispensable in ship-building for the riveting of steel frames, boilers, etc.

Stamping- or pressing-machines for making forgings by pressure instead of by hammer-blows have steadily increased in use dur-



Gould & Eberhardt Shaper.

ing the past twenty years. The best forgings are now made by pressure in hydraulic machines, the steam-hammer having been largely superseded. Other presses for shaping and punching sheet metal are now used extensively, as those for making the laminated armature for electric motors and generators.

The machining of very large castings or forgings, as the magnet frames of large electric generators, is now accomplished through the use of portable tools electrically driven, which can be applied readily to any portion of a heavy piece of work.

The development of cranes for transporting and moving heavy articles in the machine-shop has been a marked feature of American shops, and a surprising amount of money has been expended in introducing overhead electric frames designed to pick up several tons of metal and transport the load to some other part of the shop in a very short space of time.

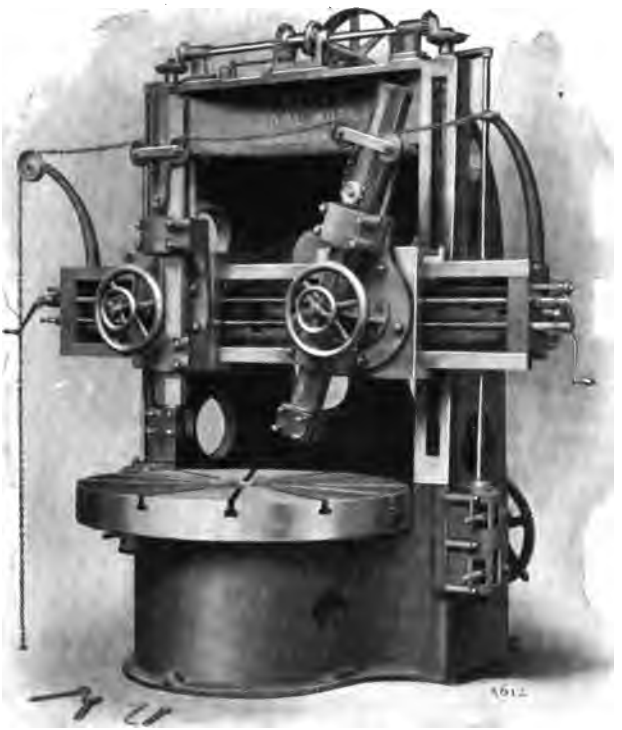
In 1888, A. J. Shaw, a Western engineer, devised an independent, series-wound reversing electric motor for each movement of the crane, and the principal defects of the mechanically driven cranes were at once eliminated. No more clutches were required; no gears to secure changes of speeds and reversals of movements; only such gears were used as were necessary to reduce the high speed of the motors to the relatively slow speeds of the hook, trolley, and bridge. Within certain limits an automatic range of speed was secured, depending on the weight of the load being handled. The introduction of rheostats designed and built especially for crane service further enabled the operator to control every movement of the crane with an accuracy and delicacy never before thought possible in a power-driven crane. (See illustration, page 616.)

Many new and difficult problems arose, but all were successfully solved. The multimotor electric travelling crane at once became popular, and the manufacturer of heavy machinery realized that his most serious difficulty had been removed.

The practice of using portable tools and bringing the tools to the work rather than the work to the tools, which is becoming so popular to-day, is a further development of the individually driven motor-tool idea. The portable tool which cannot be operated unless it is driven with individual electric motor serves as an excellent example of what we should endeavor to accomplish in our efforts to make all our machine tools as simple and useful as possible. They should not be so arranged that they must always be in one particular location in a shop, for it may be desirable to use this portion of the shop, as time goes on, for other purposes, or possibly it will become necessary to crowd in additional machines of the same type as those already in use, and it is not every shop that is so arranged as to permit of the installation of additional tools without necessitating very awkward connections to the line-shafting.

The United States census, in a special bulletin entitled " Metal-

Working Machinery," finds that in 1900 there were 397 establishments in the country manufacturing this class of machines and tools, excluding, of course, rolling-mills and the like. The capital invested was $55,000,000, and employment was given to 30,000 men. The materials used were chiefly mill-supplies, and cost nearly $16,000,000, the value of the manufactured product being over $44,000,000. Ohio, with sixty-eight establishments, was the leading



A Niles Boring-Mill.

State in this industry, employing over 6000 men, and making over $10,000,000 worth of machines and other products; Pennsylvania came next with a product of $7,000,000, followed by Connecticut, Massachusetts, and New York in the order named.

As an indication of the extended use of machine tools, the following figures are of interest: There were manufactured in the United States, during 1900, 857 power-hammers, 821 forging-machines, 7895 stamping-, flanging-, and forming-machines, 5269 punching- and shearing-machines, 914 bending- and straightening-

rolls, 202 riveting-machines, over 20,000 lathes, 23,000 boring- and drilling-machines, 1543 planers, 3076 slotters and shapers, 4119 milling-machines, 2846 metal-sawing machines, 10,014 grinding- and polishing-machines, 21,088 bolt-, nut-, and threading- and tapping-machines, besides 6751 pneumatic hand tools.

Specialization has been the keynote of success in the manufacture of American machine tools. The manufacturer who confined his work to building lathes was able to turn out better and cheaper machines than one who undertook to make a dozen classes of machine tools, and these specialists in machinery are largely responsible for the advanced position of American tools and machines, and for the fact that during the fiscal year ending June 30, 1903, we sold to other nations $97,000,000 worth of manufactures of iron and steel.

It is an undisputed fact that American machinery leads the world. In some branches we are excelled by foreign manufacturers, but in most lines we take first place. This position cannot be maintained without the continued exercise of constructive genius, backed by enterprising capital and assisted by helpful tariff laws. At this date all three of these conditions are in favor of the United States. When they change, some other nation may come to the front and rob us of our position in the race for supremacy in the world of machinery.

PROGRESS IN POWER PRODUCERS

THE greatest producer of power in the hands of man is steam. Water-power, tidal-power, gas-power, sun-power, wave-power, and electric transmission of power are all very well in certain places and conditions, but it is steam that does the work of the world to-day, and is likely to continue as the chief motive power for years to come. Water is so easy to obtain and coal so cheap to mine that the cost is trifling, and once the water is heated over 212 degrees it increases tremendously in volume, forming the gas that we call steam, which when confined develops enormous pressure, that is made use of in the steam-engine to do useful work.

That there may be no failure of understanding on the part of any as to later descriptions, let us briefly consider how the ordinary steam-engine works. As soon as steam is generated in the boiler the pressure is apparent by an indicator, set to show the number of pounds to the square inch. Almost any engine will run with a few pounds' pressure, enough to overcome its own friction, but to do work considerable surplus energy must be developed, and steam-engines are using higher pressures every day, fifty or seventy-five pounds being now thought rather low, while a hundred to two hundred pounds' pressure is becoming quite common, and some engines are built to operate at from two hundred and fifty to four hundred pounds' steam-pressure. In order to use the power developed by this pressure, in the simplest form of engine, the steam is admitted through a hole called a port to one end of a cylinder. In this cylinder is a piston-head, which is pushed along by the pressure of the steam. When the piston-head has travelled, say, a third of the length of the cylinder, the port is closed, so that no more steam comes in to the cylinder, and the other two-thirds of the travel of the piston-head are accomplished by the expansion of the steam, which seeks to fill a space many hundred times what was its volume as water. When the piston-head has been pushed to the end of the cylinder another port opens and lets out the steam, which may then pass into the air, or be farther used, as described later. In order to push the piston-head back to the point of starting, steam is then admitted at the other end, and it is forced back, the process being kept up indefinitely, causing a piston-rod to reciprocate, or move back and forth, and this piston-rod being made fast to a crank,

turns a wheel around, and thus we have rotary motion as well as reciprocating motion.

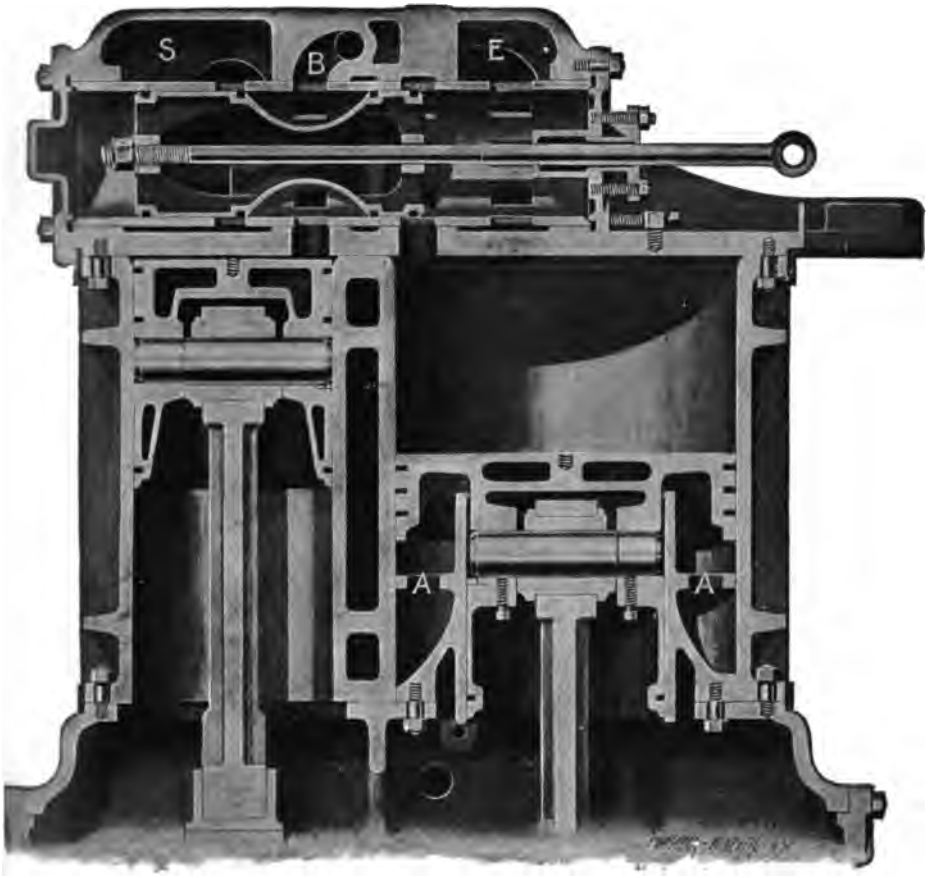
In practice steam-engines are vastly more complicated. In the best engines of this date the steam, after passing through the cylinder, is passed to a second cylinder to secure more of its expansive power, which is not exhausted; often this expansion is carried to a third cylinder, and occasionally to a fourth. Five-cylinder expansion has been tried, but is not generally approved by engineers, though in use on the Lucania and Campania, the Atlantic flyers. After being expanded to the last degree, in an economical engine the steam is directed to condensers, so that as hot water it may be returned to the boiler and make steam again quickly, without wasting a quantity of coal to raise it from the temperature of cold water. The boilers, cylinders, pipes, etc., of engines are jacketed, or covered with insulating material, to keep in the heat, and prevent its loss by radiation, thus securing more power with a given quantity of coal. In recent practice superheated steam is favored, as being more economical.

In the Westinghouse compound engine, shown in the next figure, the steam is admitted at S, and, after passing the cut-off or valve-mechanism, is admitted to the smaller or high-pressure cylinder. After being used here, the steam passes to the larger or low-pressure cylinder, where it is farther expanded, finally passing out at the exhaust, E.

Among the largest reciprocating engines built are those designed for great steamships, some of which are rated at over 10,000 horse-power, as those of the Wisconsin, illustrated elsewhere. In these the several cylinders are set upright over the crank-shaft, all of them delivering their power direct to the one shaft. Though more complicated, the principles of their construction are similar to the smaller engines. For use in factories, the horizontal type of engine is commonly employed, and this is sometimes built in very large sizes, though the best practice, where large power is required, is to have a number of engines, so that one or more can be repaired without stopping the works.

With all the ingenious devices employed, the steam-engine is very wasteful, and only delivers a fraction of the theoretical power in the coal. The rest is lost in radiation, friction, etc. Nevertheless, as has been stated, this is the most practical power we have for general purposes. While water-falls furnish theoretically cheaper power, in practice they are often not located where the power is wanted, and the building of a large dam, location of tur-

bine water-wheels, and carrying of the power away by means of electric dynamos and motors, involves the investment of a great amount of money. Therefore, the average user of small powers—say from ten to a hundred horse-power—finds a steam-engine the cheapest.



Westinghouse Compound Steam-Engine.

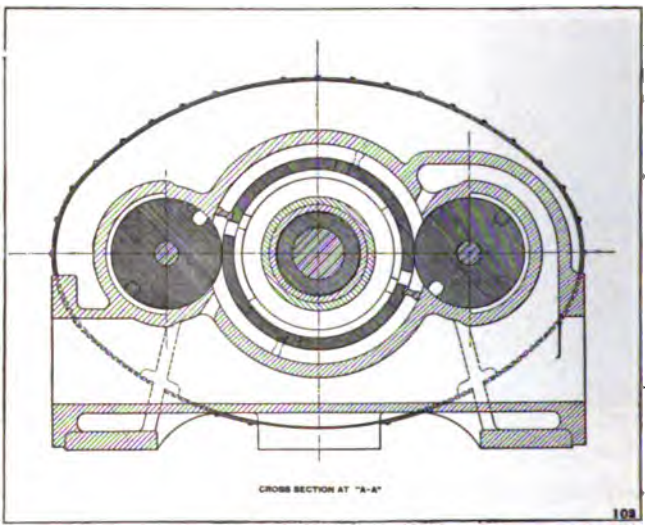
The Patent Office is strewn with the record of efforts to produce a satisfactory rotary engine. Many inventors have thought that this was the ideal engine, and that it must at some time replace the reciprocating engine. As yet, the best that can be said of this form of engine is that those made have not been sufficiently good to induce their adoption in preference to the older types of engine. There has been selected for illustration here one of the most prom-

ising rotary engines, the invention of E. C. Warren, which is manufactured by the Rotary Engine Company of Philadelphia.

The cross sectional view (Fig. 2) shows an arrangement very similar to that of all rotary engines. The piston-wheel, which is

Warren's Rotary Engine. Fig. 1.

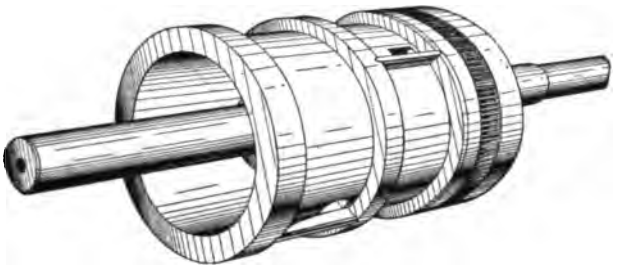
in the centre, carries a broad flange at each end and a central web, these being best shown in the perspective view. (Fig. 3.) The steam is admitted centrally through the piston-wheel, which it rotates in expanding, passing out at the exhausts (lower part Fig. 2).



Cross-Section of Rotary Engine. Fig. 2.

The rotary heads on either side of the piston-wheel serve simply to receive the webs on the piston, permitting them to pass without allowing the escape of steam. Thus far the arrangement is very similar to other rotary engines, the chief feature of the Warren

engine consisting in one end of the cylindrical piston being made a little smaller than the other end, to cause a slight end-thrust that



Piston-Wheel of Rotary Engine. Fig. 3.

tends to force the tapered wheel farther into the tapered bore of the casing, thus maintaining close joints in spite of wear on the surfaces. There is also a device for preventing an excess of end-thrust. The difficulty with most rotary engines has been that they either leaked steam or lost power because of extreme friction. Per-

Branca's Steam-Turbine, A. D. 1629.

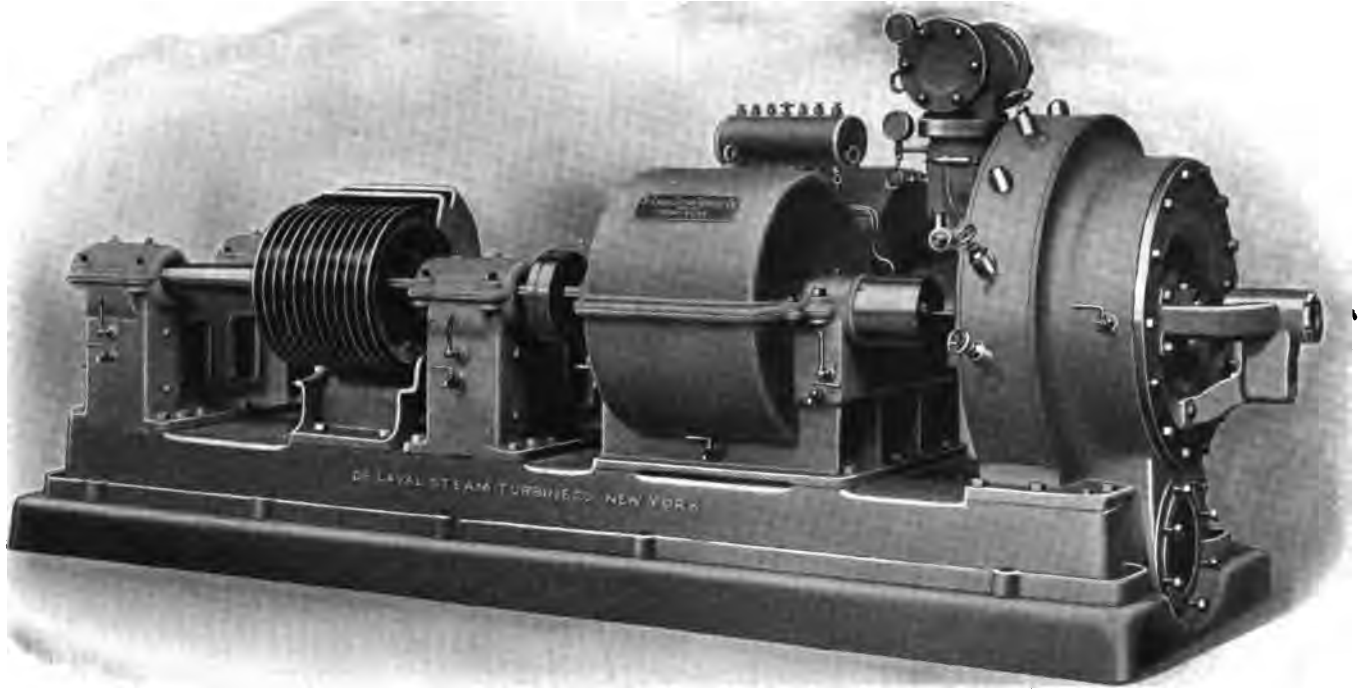
haps this engine or some outgrowth from it may prove more free from these than its predecessors.

The most notable development of steam engineering has been in the perfecting of the steam-turbine, now coming into use. This uses the steam direct, in the simplest manner, it being blown directly

against the buckets of a wheel. The idea is older than the steam-engine, dating from Hero's engine of 120 B.C. The modern type more nearly resembles the engine of Branca, made in 1629, and here illustrated, but the method was thought to be impractical, and existed only as a curiosity until 1883, when De Laval made his first successful steam-turbine. Even though successful, it has required twenty years to bring this form of an engine into moderate use. The De Laval, Parsons, and other steam-turbines are now looked upon by engineers as destined to supersede the older forms of engine for many purposes.

De Laval Steam-Turbine.

The illustration of the De Laval turbine shows so clearly what it is, that description at first seems unnecessary, yet there are principles involved not apparent on the surface. The steam is admitted from the nozzles against the curved buckets of the wheel, causing it to rotate at an enormous speed. Since no wheel is perfect, even the most carefully made De Laval wheel is bound to be heavier in some parts of its periphery than others, and when it is whirled around at a velocity of several thousand times a second this irregularity is magnified and would produce tremendous vibrations that would thump it to pieces were it not for a very simple feature. The



De Laval 300 Horse-Power Steam-Turbine Motor.

central shaft or axle is made long and thin, so that it bends readily. Therefore, when the wheel goes whirling at tremendous speed it finds its true centre of gravity very quickly, and the shaft yields slightly, accommodating itself to this. Hence there is no vibration after speed is once attained.

Another difficulty that De Laval and other designers of steam-turbines had to contend with was that the natural rotation velocities secured were much too rapid for convenient use. Under the usual conditions steam escapes from the nozzles at a speed of nearly 1500 feet a second. Uncontrolled and applied to a fair-sized wheel, it would easily drive the wheel so fast that it would burst from centrifugal force. These difficulties have been met in a measure, and small turbines are now constructed with about 500 revolutions per second, geared down to fifty revolutions for use; while in the larger sizes the speed is reduced to about 165 revolutions (of the turbine)

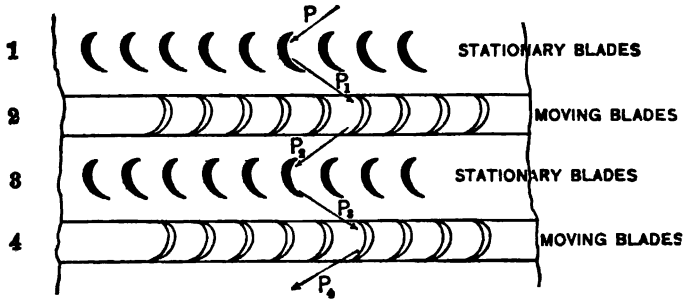


Diagram Illustrating Principle of Westinghouse-Parsons Steam-Turbine.

per second, giving usually from 600 to 1200 feet peripheral speed. This speed is reduced by means of helical spur-gears so that it is brought where it can be conveniently used to drive a dynamo or other rapid mechanism.

The Parsons steam-turbine came out in 1884, has been gradually developed, and since its use on the Turbinia, the English torpedo-boat that broke all speed records a few years since, has been greatly in favor for marine use, where high speed is required. It operates by the reaction of the steam on the vanes of wheels placed alternately with fixed vanes or blades that are oppositely positioned, the course of the steam being in the direction of the arrows P, P^1, etc. By this arrangement a series of turbines or vaned wheels are set on a shaft, and the steam passes from wheel to wheel, until its energy is practically exhausted, when it goes to a condenser.

If the steam were simply admitted at one end of a series of wheels and out at the other, the mechanism would crowd against

one side of the bearings, producing what is called end-thrust, with great resultant wear. This is avoided by the reaction of the steam in the stationary blades.

Turbines show a fair degree of economy in comparison with the older methods of using steam, and it has been demonstrated lately that the economy increases with the superheating of the steam. Professor R. H. Thurston has proven that there is a gain of about one per cent. in economy for every thirty degrees of superheat, which gain he attributes to the reduction of skin friction.

The Parsons turbine was applied to the Turbinia with a view of exploring the possibilities of high speed directly applied to the propeller-shaft. This developed the phenomenon of cavitation, which limits the practical speed of propellers, because when turned at more than a certain speed they tend to produce a vacuum, instead of exerting a pushing influence on the water. However, a new type of speedy boat was established, which is more fully described in the chapter entitled "The Race for Supremacy on the Seas." In April, 1897, the Turbinia made a mile in 110 seconds, and later reduced this to 104 seconds.

George Westinghouse said recently in an interview:

"The steam-turbine is not a new and comparatively untried invention, as many laymen seem to think. There are half a million horse-power of Parsons steam-turbines in daily operation in different parts of the world; eighty-four thousand horse-power of these are in steam vessels. In the United States alone there are 60,000 horse-power of the stationary type used in connection with electric light and power in continual operation, and 150,000 horse-power more are already contracted for and now under construction at Pittsburg, where units as large as 8000 horse-power are being built. We shall build up a great marine turbine industry in the United States. The importance of the marine turbine has not been overestimated, and it is long past the stage of experiment. For passenger ships, freight ships, yachts and for battleships, not less than for torpedo boats, the turbine is unquestionably the best engine. For pleasure craft the turbine surpasses all other forms of engine, because of its absolute freedom from vibration. Its compactness recommends it for all classes of vessels. In torpedo boats the saving of room is needed to accommodate other machinery. In naval cruisers and battleships, the engines lie so much closer to the ship's keel as to make them far less likely to be injured by the enemy's shots. We need not call the turbine the engine of the future, it is decidedly the engine of the present."

The Westinghouse Air-Brake Company put in the first large steam-turbine equipment at Wilmerding, Pennsylvania, using it in connection with their electrical power distribution system. The largest turbine erected in America up to 1903 was at Hartford, Connecticut, where a 2000 horse-power turbine is running with satisfactory results. At the World's Fair in St. Louis, the present year, an 8000 horse-power steam-turbine is on exhibition. Where

1000 horse-power or more are required, the cost of the engine-room and outfit is about half what it would be with reciprocating engines.

In addition to the De Laval and Parsons turbines, which have been mentioned, a Curtis turbine is also manufactured, and in France and Switzerland the Rateau turbine is used, both of these being very similar to the De Laval. While at present the turbine has shown itself useful principally for connection with dynamos, where very large powers are used, and for torpedo-boats, and, in a small way, for cream-separators, the fact that it has in these fields in twenty years outstripped the reciprocating engine with its two hun-

Waste Water Returning to Niagara River after Furnishing Power to Factories.

dred years of development, suggests a very much enlarged field for it in the near future. Its advantages may be classified as follows:

1. The steam is applied directly, without intervening mechanism that involves friction, lost motion, etc.

2. All the parts are rotating, permitting the highest speeds.

3. It occupies very much less space than a reciprocating engine, requires a lighter foundation, and weighs less.

4. It has no dead centre, but will start in any position.

5. No valve-gearing whatever is used.

6. It is cheap to build and cheap to buy.

7. The condensing of the steam in the engine does no harm, as with reciprocating engines.

8. It is started by turning on the steam and stopped by turning it off.

9. The absence of vibration renders it very valuable for marine use.

10. Its low centre of gravity is an advantage in a steamship.

11. There are very few parts to break, and the wear is trifling.

12. Its efficiency between full load and half load varies but little.

Next to the steam-engine comes the gas-engine, which derives its power from exploding a mixture of coal-gas (that may be common illuminating gas) with air. These are patterned after the steam-engine in that they have a cylinder, ports, and a crank and piston. In the usual form they drive only from one end of the cylinder, giving an explosion every other stroke, the intermediate stroke being required for the compression of the exploding mixture. Ordinary city gas is admitted by a valve, and another valve admits air to the space over the piston in the cylinder. When these are admitted in the proper quantity and compressed and ignited by either a flame or electric spark there is an explosion, the force of which is nicely regulated, so that injury is impossible, and it simply serves to drive the piston and incidentally the large fly-wheel, which stores the power until the next explosion.

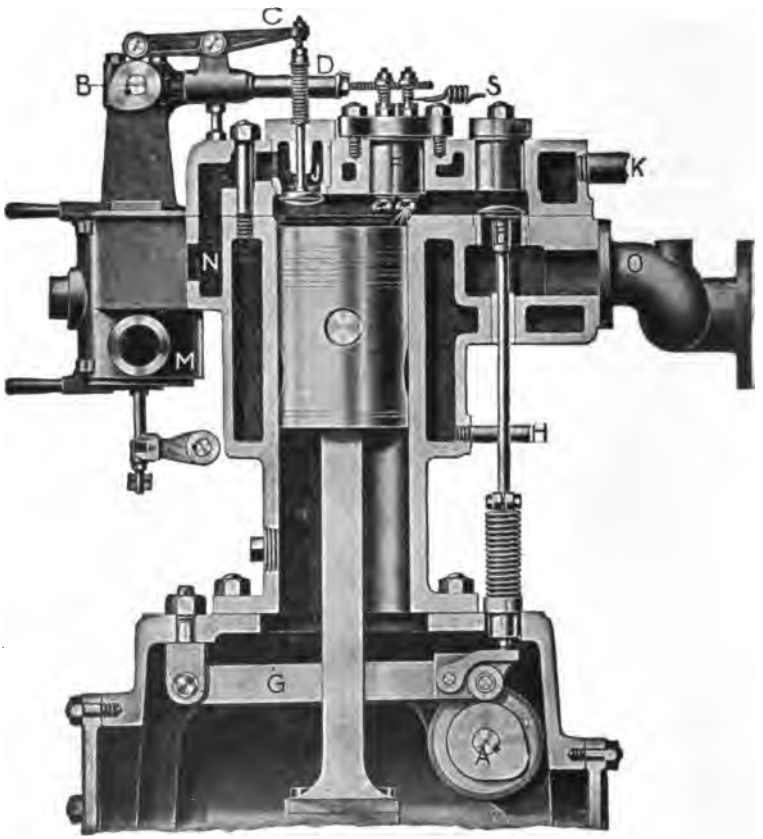
The common method of burning coal to supply heat and power is theoretically wrong, as demonstrated by the low cost at which fuel gas can now be manufactured and the economical power that can be obtained through large gas-engines. When we burn coal in the ordinary way, we simply get the benefit of the coal-gas in it and of the coke; but when we manufacture the coal into gas by the most recent improved water-gas process we obtain from the water an additional quantity of gas, eight or ten times as great as is obtainable from the coal alone. In other words, through the use of coal we release the hydrogen from the water so that we may use it to burn.

Under the best conditions, fuel gas can be thus produced at a cost of probably one-fourth the price usually charged to the consumers of gas in the cities, and this makes not only a cheap fuel, but, when used to produce explosions in the gas-engine, results in a most economical form of power.

Mond gas is a comparatively new article, which is being introduced for use in gas-engines and for heating purposes. It is manufactured very cheaply, because it utilizes the very cheapest coal, viz., the slack or dross; and it has been produced on a large scale at a cost of less than one cent per thousand feet; a gross ton (that is, 2240 pounds) of rough slack coal will produce about 140,000 feet

of Mond gas of good heating quality, and when this is used in a large gas-engine it will furnish 2500 horse-power hours. It works better in gas-engines than does the ordinary city gas furnished for lighting purposes.

In the larger gas-engines there are two, or three, or more cylinders, but until a few years ago gas-engines were thought suitable only for small powers. The largest gas-engine shown at the Pan-



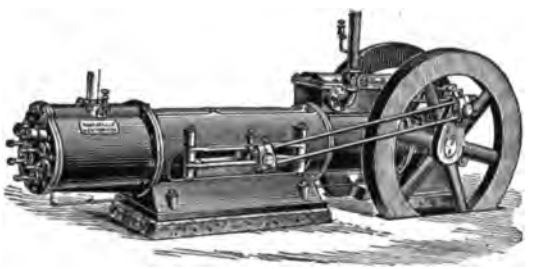
Westinghouse Gas-Engine.

American Exposition in 1901 was of 300 horse-power, while at St. Louis in this year, 1904, there is on exhibition an Allis-Chalmers gas-engine of 2000 horse-power, and another of German make of 1750 horse-power.

The illustration shows the working of a single-cylinder Westinghouse gas-engine. The piston has just reached the upper limit of its compression stroke, and the inlet-valve, J, and the exhaust-

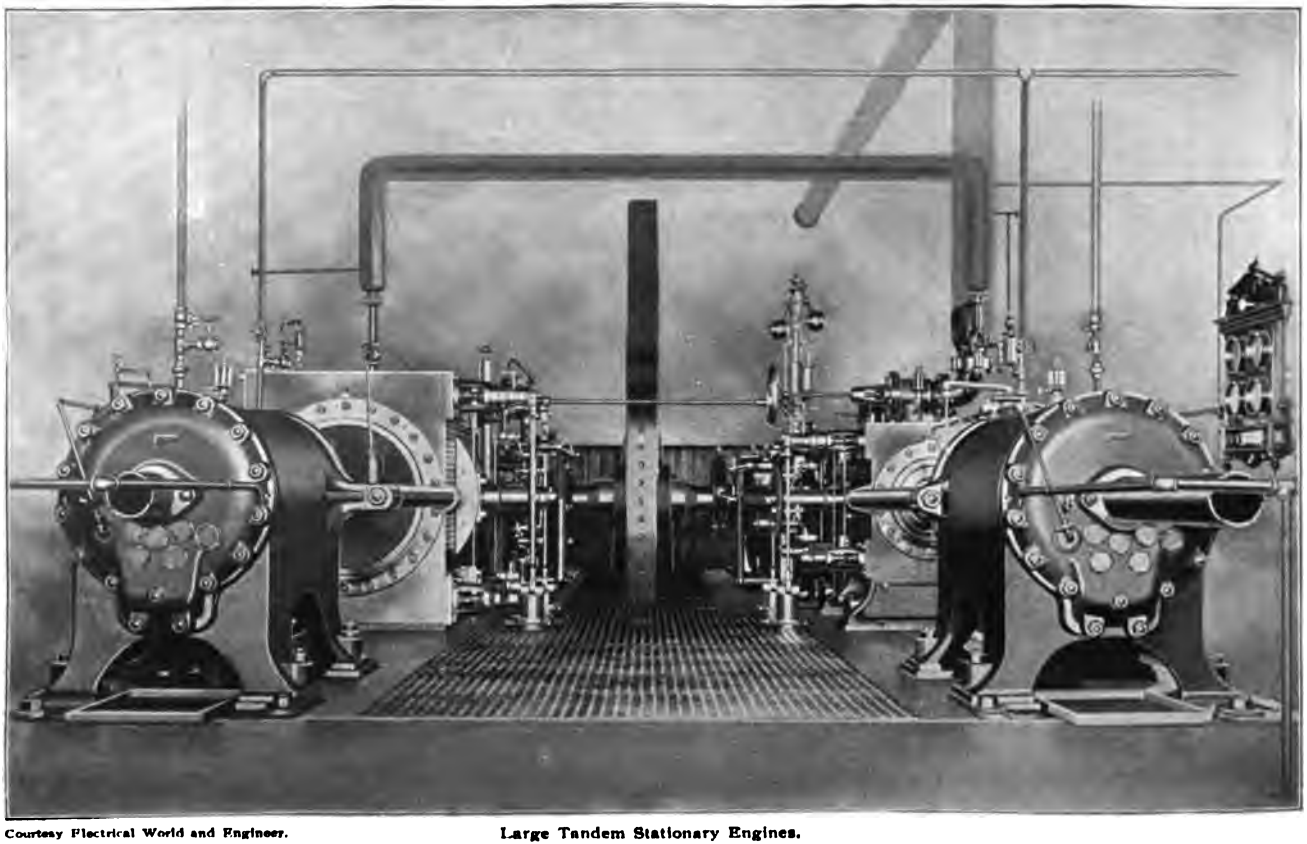
valve, E, are both closed. At F is the igniter just ready to flash. Its terminals are about to be separated by the spring in the guide, D, and when they separate the spark is formed that ignites the charge in the space above the cylinder. The ignition burns the gases, which immediately rise in pressure, this constituting the explosion, and the piston is forced down.

The Koerting double-acting, two-cycle gas-engine, built by the De la Vergne Machine Company, of New York, marks a new departure in explosive engines. One of the drawbacks of these engines in the past has been that they explode at every other stroke, for this reason requiring very heavy fly-wheels to maintain a steady power. The Koerting engine has a double-ended cylinder, and receives the combustible mixture of gas and air at the centre of the cylinder, this arrangement making it double-acting, so that it is possible to reduce the size of the fly-wheel, producing a machine that much resembles a horizontal steam-engine.



The Rand Direct-Acting Steam Air-Compressor.

Compressed-air motors are used in many instances in preference to steam-engines. For locomotives for underground use in mines and tunnels they have the advantage of developing no noxious gases; in fact, they tend to improve the atmosphere by releasing pure air. They operate with a cylinder or cylinders, like the steam locomotive, but there are numerous differences in the construction growing out of the conditions. A steam-engine is always hot when in use; a compressed-air engine also develops heat by compression of the air as well as frictional heat. The best results are obtained in those compressed-air engines that heat the air at the final using, in order to secure the most expansion. To avoid as far as possible the loss of heat involved in using compressed air, the usual method is to compress the air in three stages, so as to recover the heat developed in compression by means of circulating water about the cylinders. The heat generated in compression thus serves to



Courtesy Electrical World and Engineer.

Large Tandem Stationary Engines.

assist in heating water for the boilers used to drive the engine that does the compression.

After compression, the air, which has been cooled, is stored in steel tanks at a pressure often as great as 2000 pounds to the square inch. From such tanks it is passed through a reducing cylinder, so that it can be used at a pressure somewhere between fifty and a hundred and fifty pounds. If heat is used for expansion, the moisture is turned to steam, and still further aids the expansion of the air and consequent development of power.

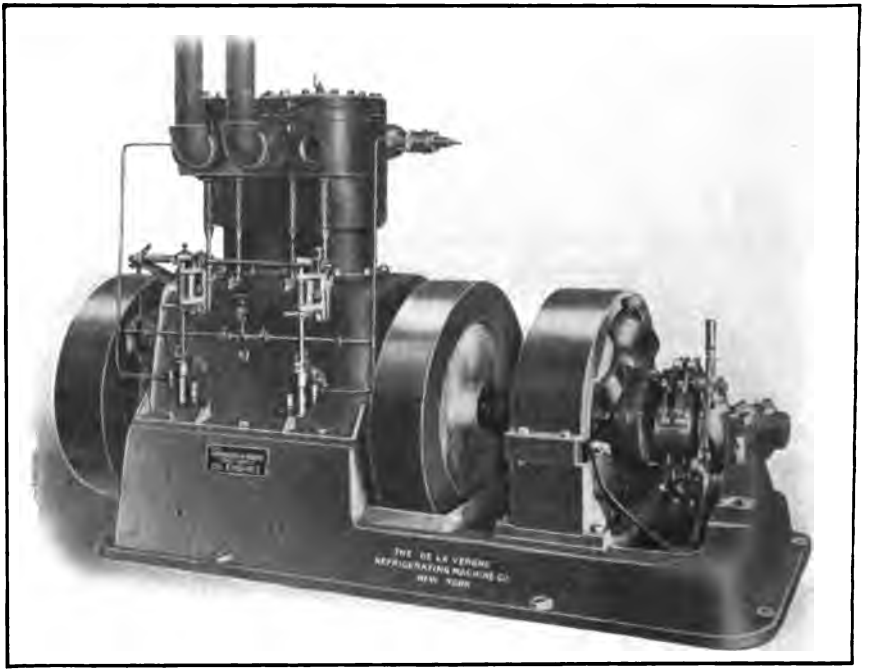
Oil-engines are made in a variety of forms, many of them being simply steam-engines arranged to burn oil as fuel instead of coal; others are so different in construction as to require a special description. The type commonly denominated as a gasolene engine is much used on motor-bicycles, automobiles, etc. These operate by permitting gasolene to issue in a very fine stream into a vaporizer, so that it is turned to gas, which, being mixed with air and ignited in a cylinder by an electric spark or flame, explodes, producing a pressure for driving the cylinder.

In order to satisfy the demand which has arisen for direct-connected outfits the De la Vergne Machine Company, of New York City, have recently put on the market a vertical type of two-cylinder oil- or kerosene-engine, the Hornsby-Akroyd, which is shown in the accompanying illustration. The fifteen horse-power size shown runs at a speed of about 450 revolutions per minute. The crank-shaft of the engine is rigidly connected to the dynamo by shaft coupling. The crank-pins are set in line, and on each explosion a revolution of the crank-shaft is obtained. The engine operates on the four-cycle plan, consequently proper combustion is obtained in the cylinder. The fuel is supplied to the vaporizers by two separate oil-supply pumps, accordingly the engine can be operated as a single-cylinder engine should it be desired to do so. The regulating speed governor, the most important feature of direct-connected outfit, is the Rites patent governor placed in the fly-wheel of the engine. The regulation of speed is effected by automatically varying the length of the oil-pump stroke. Thus, if the load on the engine is decreased, the governor, by means of an eccentric, suitably decreases the stroke of the oil-pump, varying exactly the pressure in the cylinder to suit the load which the engine has to overcome. Practically perfect regulation of speed results, and the makers claim a variation in speed of less than two per cent.

The consumption of oil in this engine is stated by the makers as less than one pound per actual horse-power hour. The fuel used

is ordinary kerosene, crude or fuel oil. When using kerosene the cost of operation is approximately one cent per horse-power hour; with crude oil this cost may be less than one-half cent. The operation of this engine is entirely automatic and it requires no adjustment whatever, the only attention necessary being the heating up of the vaporizers for five or ten minutes before starting, and occasional lubrication afterwards.

A variety of motors have been built using unusual motive fluids. An ether-motor for automobiles is described in another chapter. An



Hornsby-Akroyd Oil-Engine.

ammonia-motor has been built, to take advantage of the very low temperature at which ammonia boils or vaporizes, the theory being that it would require very little coal on this account, and that the ammonia would not be costly, being used over and over. But neither of these has proven practical for ordinary uses.

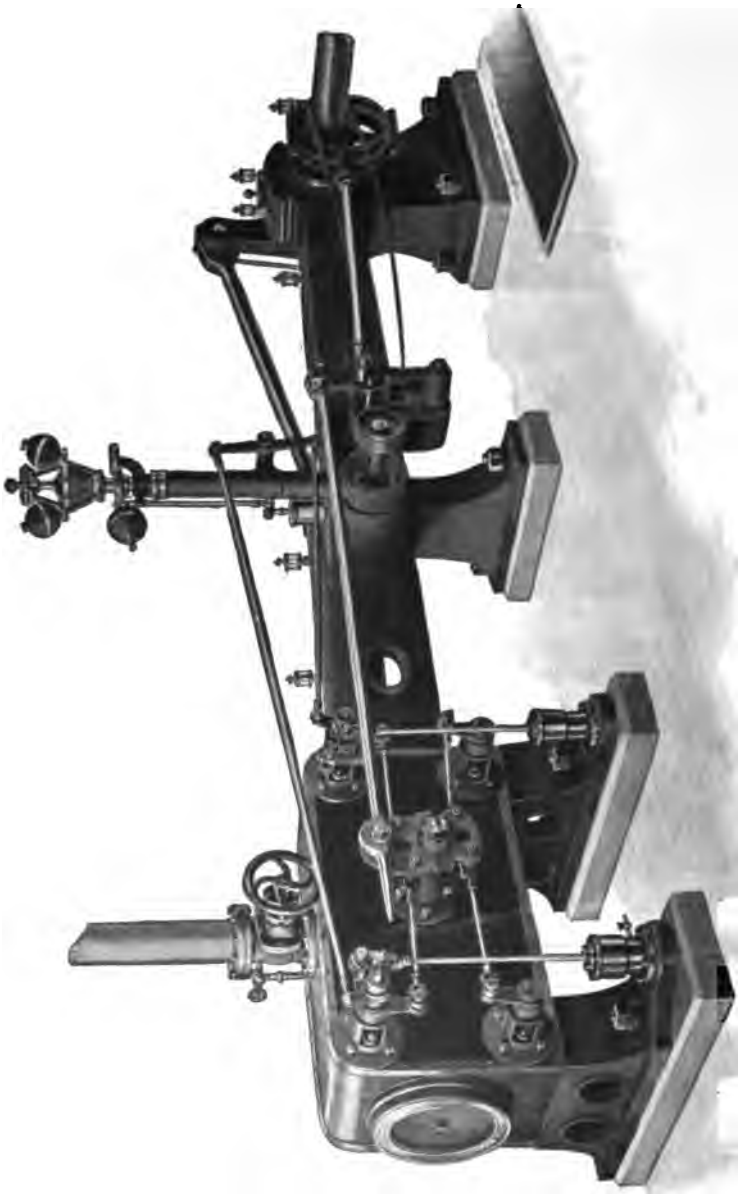
The electric motor deserves some consideration here, for, though not a producer of power, it is used to deliver it, and, as far as users are concerned, is viewed very much in the same light. The small electric motor has displaced the small steam-engine in a great many

places, the user preferring it, and leaving the task of supplying the actual power to a power company operating huge steam-engines to drive their dynamos, or in some cases securing water-power. The steam-engine or water-wheel turns the dynamo, and this converts the energy into electricity, which is sent out over wires to the users of small motors or for various other purposes. It is estimated that there are over 60,000 small electric motors in use in the United States, costing $12,000,000 and supplying 1,000,000 of horse power. Users of machinery find it best to equip all large machines with individual motors, and in this way not only make their operation independent of other machines, but also save the expense of surplus power and of running shafting and belts when the machine is idle. While electric motors have cost more in some cases than steam-engines, and while the charge for electric power was usually higher per horse-power than that paid direct for steam-power, yet the saving in shafting, belts and friction, and reduced time of operating have more than offset these. Nothing will stop the introduction of a machine that saves money, and the electric motor proved a saver, although it usually delivered power from some other prime motor; but in that case it was a better and more economical engine, and the motor was better than the shafting and belts it displaced. The introduction of the small motor also afforded more light and room in factories, printing-offices, machine-shops, etc., where it was used, and there was less dust and dirt and fewer repairs.

The question of whether or not power shall be distributed in machine-shops by means of electricity is to-day hardly considered, as the advantages obtained by this method have been so successfully proven that there is little room left for doubt. Besides eliminating the disadvantages of line shafting, belting, and the inflexibility of location, the individual drive of machine-tools by electric motors increases the efficiency and output. There are numerous minor conveniences coming with the employment of electric motors, such as that in a growing manufactory, as each new machine is added a little motor comes with it, and there is no overhauling of the engine-room every little while to get more power; it is easier to move or relocate machines, and the bother of oiling shafting, keeping it in line, and tightening belts is avoided. The result of all these desirable features of electric driving by motors is not only lower cost, but increased output and larger profits.

The water-wheel is the oldest power we have, and the modern turbine is the best means of utilizing it, except where very high heads or pressures are obtainable, and then tangential water-wheels, of the

Pelton type, somewhat resembling the De Laval steam-turbine, produce the best results. The turbine finds its highest development in

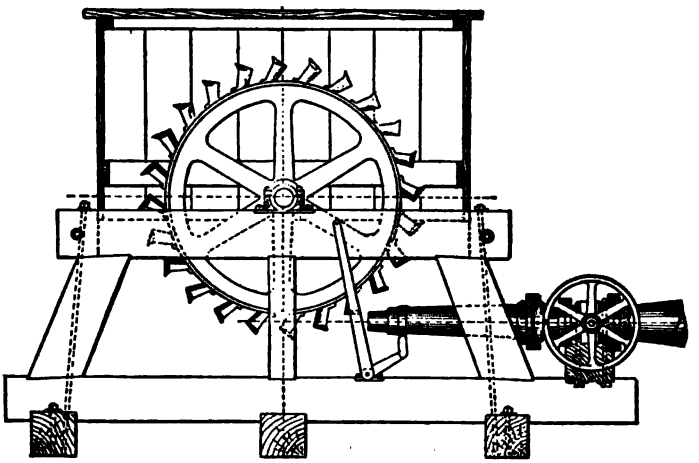


A Mining Engine, made in Sections for Transportation on Muleback.

Courtesy Allis-Chalmers Co.

the installation at Niagara Falls, where a series of 5000 horse-power dynamos are directly driven by turbines, specially designed to re-

ceive the impact of water after a fall of 136 feet. This power station has been described so often that it seems superfluous to more than mention it here. The Pelton type of wheel for high water-heads is not so well known, its use being confined largely to Western mines where a high head of water is obtainable as a source of power. This wheel is simplicity itself, and depends for its successful working upon the exactly scientific construction of its parts and the use of great pressures. It is a simple wheel with a series of buckets around its periphery, into which the water is directed from a nozzle. To increase the power of the wheel two parallel rows of buckets are sometimes employed, with two or more nozzles to each row. It is principally manufactured in small sizes for high speeds, and a



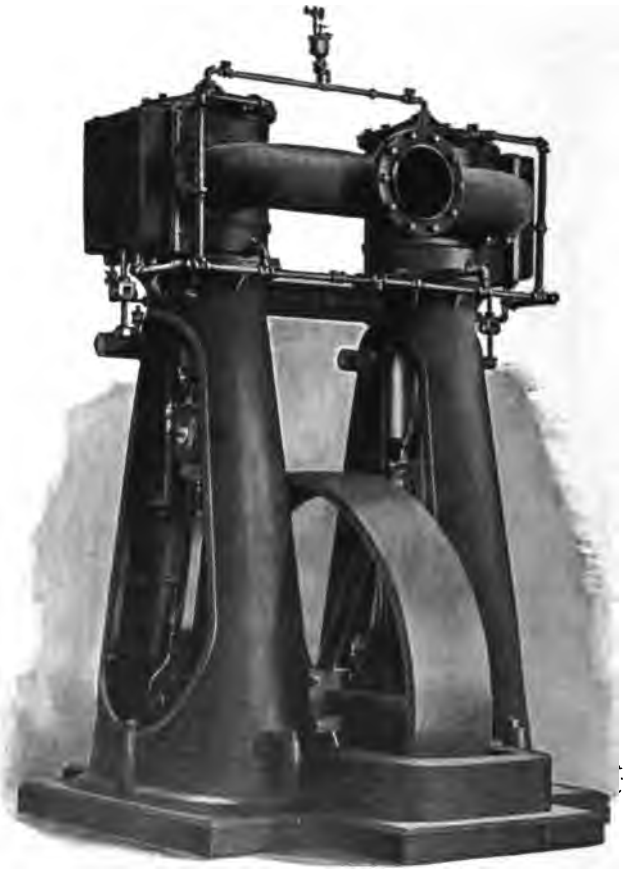
The Pelton Water-Wheel.

small Pelton wheel with high head of water and several nozzles is quite satisfactory for direct connection with a dynamo or other high-speed machine.

The amount of power obtainable from one of these wheels under high pressure is remarkable. Suppose a location 250 feet below the level of the water supply, and plenty of water; put in a six-foot Pelton wheel, and you can get out of it 267 horse-power with one nozzle, or 534 horse-power with two nozzles—a very convenient power to have. A three-foot Pelton wheel, located in the Comstock mine, in Nevada, 1640 feet below the surface and operated under a water-head of 2100 feet, develops 100 horse-power with a half-inch stream of water. A tunnel four miles long carries off the water. The surface velocity of the wheel is 120 miles an

hour, and it would be double this if it was not reduced by the load, or resistance of the machinery it has to drive.

Tidal-motors and wave-motors have never secured general recognition. These are based on great natural powers going to waste, and at first sight it appears as if engineers had been very lax in not developing machinery for economically using the rise and fall



De la Vergne Upright Pumping-Engine.

of the tide, and the inrolling of the surf. But all the methods so far tried have failed of commercial success because they either cost more or did not do the work as well as a steam-engine. While there is enormous power in a rising and falling tide, yet it requires a very large and costly mechanism to use it, and it does not give forth its energy for about one hour in every six of the day, which means that the users of the power must either remain idle during the turns

of the tide, or fall back on some other power, or go to further expense to store the tidal power to be used as wanted. In the case of wave-motors, their operation is more or less intermittent, though some very excellent ones have been built; but the best of them are liable to destruction about once a year, because so exposed to storms, and they are not seriously considered by power users.

The windmill has come into considerable use for water-raising on farms, and that is about all it is good for, as wind-power is one

The Los Angeles Sun-Motor.

of the most uncertain of Nature's forces. Except that windmills are built better and cheaper than they used to be, there has not been much change in them for several hundred years.

Sun-motors have been discussed by many and built occasionally by some enterprising experimentalists. Such motors would be specially useful in a desert region, where water is scarce for a steam-engine and where sunshine is plenty and reliable. Ericsson tried his hand at building one in 1884, but it was not a commercial success. A few years ago a company was formed that built several,

of which the latest and most successful was located at Los Angeles, California, and is here illustrated. It consists of an immense reflecting surface, thirty-three and one-half feet in diameter, made of 788 small mirrors, all positioned to throw the sun's rays on a central boiler of peculiar form. Of course the entire apparatus has to swing with the sun so as to always face the blazing orb.

The boiler holds a hundred gallons of water, and has eight cubic feet of steam space besides. Starting with cold water, the heat is sufficient to raise steam and get up a pressure of 150 pounds in one hour. By means of a condenser the water is used over and over again. Some idea of the heat generated within the reflector may be gained by thrusting a stick of wood within its influence; it blazes up like a match touched to a hot stove. The machine is wholly automatic, being self-oiled. When once set properly facing the sun, it takes care of itself for the remainder of the day, delivering its power through a peculiar form of gearing to the ground level. The motor shown in the illustration was used for pumping for irrigation, and lifted 1400 gallons a minute. In this size it has a capacity of about ten or twelve horse-power.

For descriptions of other motors see the chapters " Revolution in Vehicles and Roadways," " The Race for Supremacy on the Seas," and " The Iron Horse and the Railways."

COTTON, WOOL, AND TEXTILE MANUFACTURES

No industry is more important than the manufacture of textiles, for on this we depend for our clothing—a prime necessity of civilized existence.

Men began to wear clothes before the dawn of history. Their first clothing was made of the skins and furs of wild animals they had killed. When weaving became common, the woolly animals were in demand to give up their long fleece to make clothing for men who had wandered to chilly climes. That weaving was understood many thousands of years ago is positively known by the garments and cloths found about Egyptian mummies of vast age. Egyptian and Assyrian as well as Mexican carvings also indicate clothing that was woven rather than made of skins.

From the white and fleecy filaments of the cotton burr we derive the cloth for the million, low in cost and as useful in a thousand ways as the higher-priced fabrics. From the tangled wool of the bleating sheep and can-devouring goat we secure the tough warm fibres that go to make the strongest and most durable of fabrics for heavy clothing, giving warmth and having great endurance against wear. From flax we derive material for our table linens and summer gowns; from jute we make our bagging, and from hemp the rope that forms a ship's hawser or a hangman's knot. From the tiny thread of the silkworm we weave the most beautiful and costly fabrics of fashion, the satin and silk gowns of queens, the chiffon, gauze and lace that grace the costumes of the highest in all lands. Such are the materials of the textile world, but the description of its progress is a tale of more prose than poetry. While cotton, wool, silk and other fibres entering into the manufactures of textiles are widely different in their origin, and might be considered separately, yet as soon as one begins to discuss the manufacture the subjects draw together and overlap. There is no such thing as separating cotton-making wholly from woollen manufacture; and the same can be said of silk. True, there are cotton-mills, woollen-mills, and silk-mills; but the goods that reach the public contain so many combinations of these and other fibres that it seems best to consider them under this general heading in order to secure an intelligible view of the whole situation.

The United States stands second among the countries of the

world in the cotton industry, is tied for third place in woollens, and nearly tied for first place in silk. Great Britain leads us in cotton, Great Britain and France lead us in woollens, and France led us slightly in silk in 1900, but it appears very probable that in this year, 1904, we either equal or excel her in this industry.

Cotton was the leading manufacture among textiles of the United States up to the time of the Civil War, when it suffered a decline, and it was not until the close of the nineteenth century that it again came to the front and took precedence over wool. At this

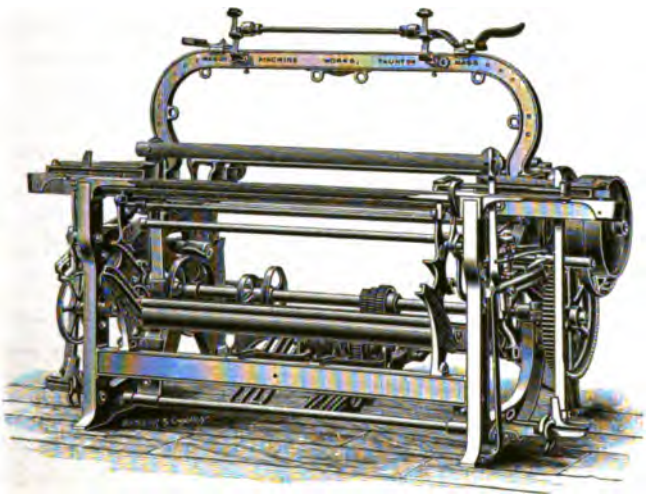
Courtesy Scientific American.

A Steamer Laden with Cotton.

writing the cotton industry stands above all other textiles in capital, number of persons engaged, amount of wages paid, and value of products, though wool is a little in advance in the cost of material employed. The woollen industry of the United States dates back almost to the time of the Pilgrim Fathers. Wool-carding can be carried on in a small way that is impossible with either cotton or silk, and therefore it is made into cloth in nearly all parts of the globe, except those under a torrid sun. For this reason our woollen industry has always been a considerable one, and has grown with the nation as a whole.

In 1870, after the war, conditions had been largely improved.

the total consumption of the country in cotton, wool, and silk amounted to $466,000,000, of which we imported a little over one-sixth. In 1900 our consumption was $896,000,000, of which we imported but nine per cent. The value of the domestic product at the present date, it is safe to state, is nearly or quite double what it was in 1870. The largest part of this growth is in the cotton industry, but the greatest proportional growth is in silk manufacture, which amounted to only $12,000,000 in 1870, and rose to $107,000,000 in 1900. The cotton industry has doubled in the value of its output and shown a tendency to concentrate, the improvements in machinery and the costliness of plants tending to throw the business into the larger manufacturing plants.



Mason Manufacturing Company's Loom.

In recent years there has been a considerable growth also of the cotton industry in China and Japan and the East Indies, owing to favorable conditions for cotton growing; and in Canada and Mexico largely because of governmental assistance. The growth of silk manufacture in the United States is presumed to be due to the fact that general prosperity has caused a demand for it as a wearing material. We do not raise silkworms, but have to import the raw material, and silk is not a serviceable dress material, having little to recommend it but its beauty. Almost all of our silk-mills are located in five adjoining States—Pennsylvania, New York, New Jersey, Connecticut, and Massachusetts. Of the $395,000,000 worth of silk produced by the mills of the world in 1900, France made $122,-

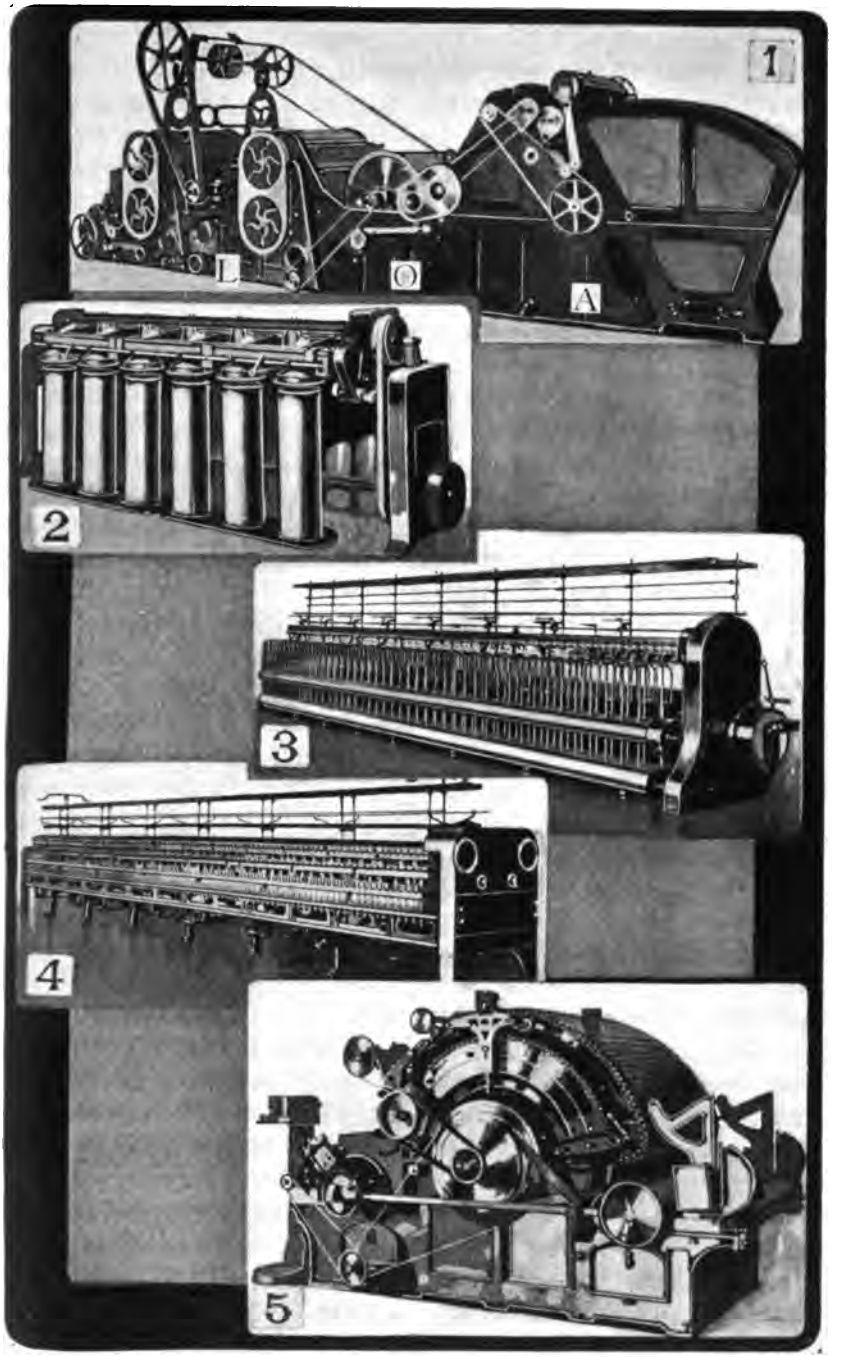
000,000, the United States $92,000,000, Germany $73,000,000, and other countries minor quantities. The French method of making their figure does not afford quite fair comparison with the United States, and this, taken with the known fact that our silk-mills have developed steadily since 1900, renders it probable that we are now quite on a par with France in this article of manufacture.

The cotton crop of the United States reached its largest proportions in the years 1898 and 1899, during each of which over 11,000,000 bales were produced, this being about three-fourths of the world's supply. During recent years our average cotton crop has been a little over 10,000,000 bales of 500 pounds each. Of this we use about forty-five per cent., and export the remaining fifty-five per cent. to Great Britain and the continent. No other country approaches us in cotton growing, but when it comes to cotton spinning Great Britain can show a trifle over two spindles to our one, while continental Europe operates one and a half spindles to every spindle in the United States. Texas is the leading State in the production of cotton, Georgia, Mississippi and Alabama coming next.

Statistics of the woollen industry are less reliable than those of silk and cotton, because the business is in so many small hands. We use about 400,000,000 pounds a year, Great Britain about 500,000,000, and the continent of Europe about 1,250,000,000 pounds. Great Britain stands first in wool consumption and manufacture, then France, the United States, Germany and Austria in the order named, Great Britain probably not making more than thirty per cent. more than Austria.

In addition to the cotton, wool, and silk manufactured products of the United States, which total up $745,000,000 for 1900, we manufactured $95,000,000 of hosiery and knit goods, 48,000,000 of flax, hemp and jute, and $45,000,000 that the census classifies under the heading " dyeing and finishing textiles." There are more than four thousand concerns engaged in the textile industries of the United States, which is less than the number in 1870, though the volume of manufacture has doubled. The tendency to consolidate in large concerns is most conspicuous in the cotton branch of the textile industry, and the average capital of the thousand cotton manufacturing concerns in the country is now nearly half a million dollars each. The total number of wage-earners in all the textile industries of the United States in 1900 was 661,451, of whom half the adults were women and ten per cent. were children.

Generally speaking, the manufactories of cotton have supplied



Cotton Machinery.

1, L, Lapping-machine; O, opener; A, feeder. 2, Drawing-frame; 3, slubbing-frame; 4, spinning-frame or spinning-mule; 5, carding-machine.

the bulk for home consumption since 1825. Although we have imported considerable cotton, it has been of sorts that our manufacturers never undertook to make. Plain cotton cloth constitutes the great bulk of our manufacture, and during times when the home market has been glutted, our manufacturers have been able to save themselves by shipping the surplus abroad. In 1900 we imported cotton goods to the value of $41,000,000 and exported to the value of $24,000,000, both figures exceeding any previous year.

Geographically, our cotton industry belongs to the South, East, and Middle States in the order named. There is practically no cotton industry in the West. The doubling of our cotton industry in the past thirty years is mainly owing to the great development in North and South Carolina, Georgia and Alabama within the past fifteen years.

The practice of mercerizing cotton has much increased within a dozen years past. Formerly cotton was mercerized largely for the purpose of improving its fibre and increasing its strength. The mercerizing process consists in treating the yarn or woven goods with a solution of caustic soda, and then washing out the soda with dilute sulphuric acid and water. The operation renders the fibre smoother and more cylindrical, but causes large shrinkage, thus reducing the quantity as measured by the square yard. The reintroduction of mercerizing is due to the modern method of performing the mercerizing under tension, thus stopping the loss from shrinkage and at the same time securing the benefit of the improved smooth fibre. Cotton mercerized under tension—not stretched, but simply held against shrinkage—becomes more translucent, has a smoother surface, and acquires a lustre that suggests silk, and renders it more salable. The value of the United States cotton product during 1900 was increased $680,000 by mercerizing.

The principal machines used in cotton manufacture are the loom, developed mainly by Arkwright; the scutching-machine, invented by Snodgrass; the carding-machine, which owes its principal development to the Messrs. Ashworth, and the spinning-mule, invented by Crompton and developed by Roberts. The spindle was continually improved up to the time of the Rabbeth spindle, which appears to have attained the practical limit of speed, about 10,000 turns a minute. During recent years inventors have turned their attention largely to the problem of reducing the stoppages of machines, most of them being made to stop automatically on the breaking of a thread or the exhausting of a shuttle. The most conspicuous success in new machinery since 1895 has been the Northrop

loom, which inaugurated two fundamental improvements with filling-changing mechanisms and warp-stopping devices. The former reduces to a small fraction the time needed to supply a loom with weft, giving the weaver more time to attend to breaks, and it is also practicable to use larger cops of filling yarn, so that these do not require to be renewed as often.

The basic principle of weaving was discovered so long ago that its origin is lost. It will be best understood by describing a very simple form of loom. Imagine a series of two hundred threads, each a hundred feet long and stretched parallel, with one set of ends held by one beam and the other set of ends held by another beam. By slowly turning one beam, the threads may be wound up on it and unwound from the other beam. Suppose a cross-stick between the two beams with a hundred little rings on it, and that every other thread passes through one of these rings. The threads represent the chain or warp, and at one side wound around a bobbin in a shuttle is a long thread, which is to form the filling, or weft, or woof, as the cross-threads are called; the stick and rings represent the loom harness. If the cross-stick with its rings be raised a few inches, every other thread of the warp will be raised also, and the shuttle can be passed across to the opposite side. If, then, the cross-stick be lowered to bring every other thread down a few inches, the shuttle may be sent back again, this time passing above the threads that on the previous passage were below it. By repeating this operation and advancing the warp slowly, a web of cloth is formed, with the threads crossed in the ordinary manner. The part of a loom which we have described as a cross-stick with rings is technically called a "dobby," and the illustration shows the form manufactured by the Mason Machine Works, of Taunton, Massachusetts. This dobby operates on what is called the Hattersley principle, and raises and lowers the loom-harness.

To cross threads differently, so as to form a pattern, the Jacquard cards were devised. A set of punctured cards is passed over a flat-sided cylinder. The arrangement of the holes in each card determines the position of what corresponds to the rings on the cross-stick or harness described, and results in raising a thread, or not raising it, as the pattern requires. By providing a card for every cross-stroke of the shuttle, any desired pattern of weave can be produced. A book in imitation of a printed book has even been produced in this way by a German, and several copies made, one of which is in the possession of Theodore L. De Vinne, of New York.

When the threads of a fabric are interlaced in the simplest pos-

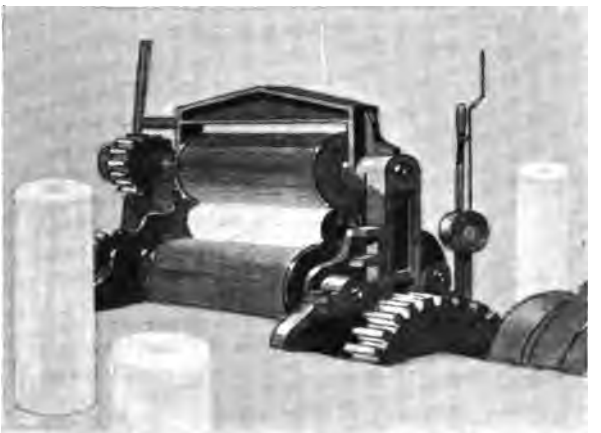
sible manner, as described, it is called a plain weave. A twill is produced by carrying the shuttle over one and under two or more warp-threads, giving what is called a twill appearance, or in extreme cases a diagonal effect. The satin weave is produced by crossing the threads a reduced number of times, so as to make the surface as smooth as possible, the glossy face of satin being obtained by finishing between hot rollers.

In pile-weaving for carpets and the like, there are two warps, one of which is regularly drawn over wires to form loops which are left in. Brussels carpet has uncut pile and Wilton a cut pile.

A Dobby.

Cotton requires to be baled near the place where it is grown and shipped to the point where it is to be manufactured. In order to transport economically, it is necessary to compress it tightly, because of its bulk, which is greater for its weight than that of almost any other common article of freight. A railway car could carry cotton most economically if compressed to a weight of about fifty pounds to the cubic foot, hence all excess over this causes an increased freight charge. The original compressor was a black slave, using his feet and a pounding-bar. Then a condenser was

made a part of the cotton-gin, this having a screen, against which the cotton was blown, the dirt passing through, and the cotton forming a bat or layer that was rolled up tightly. Then a screw-press was built, and usually operated by mule-power, for compressing the cotton as much as possible. This was naturally followed by a steam-press, which applied more power and crowded the cotton closer. These steam-presses have been built to exert as great a pressure as 6,000,000 pounds per bale; but though this is capable of reducing the cotton to a density of about sixty pounds to the foot, it will not stay there when baled, as the wrapping material is not strong enough to hold it, and steam-pressed cotton bales are commonly made all the way from twelve to twenty-two pounds to the foot.



Round Cotton-Bale and Press.

To improve the cotton bale the American Cotton Company developed the cylindrical bale, formed of a bat or layer of cotton, wound on itself so that the cotton tends to hold itself, each added layer tending to compress the interior layers. In their bat-forming and condensing-machine the cotton is condensed by a drum, crowded down between aprons and compressed between a series of rollers. With this machine, driven by twenty-five horse-power, bales have been made of a density of eighty-six pounds to the cubic foot, which is about fifty per cent. greater solidity than oak wood. This method of compression, forming a close bat and winding it up tightly, of course forms a cylindrical or round bale, as it is generally called, which form is wasteful in loading and packing as compared with a rectangular bale; however, the compression secured is so much

greater finally that there is a saving in transportation. The round bale has the advantage that it arrives at the cotton-mill entirely protected by bagging and without wires or hoops, the result being a reduction in the tare or waste by dirt. The lapped round bale is better for the use of the mill, as the material is comparatively clean and in good shape, and does not have to go through the breaking lapper.

The makers of round-bale machinery claim that a warehouse will hold forty per cent. more cotton in round than in square bales, and that the danger from fire is much less, as shown by reduced insurance rates. The machine for round-baling weighs about one-twentieth that of a square-baling press, the gain coming from the fact that the compression is done in detail rather than in bulk. As commonly made, the round bale is thirty-five inches long, twenty-one inches in diameter, and weighs 250 pounds, giving a density of thirty-five pounds to the foot.

In 1900 there were 1414 woollen manufactories in the United States, having a capitalization of $310,000,000 and employing 160,000 persons, of whom a little over half were men. The value of the product they turned out was $296,000,000. The largest business is carried on in the States of Massachusetts, Pennsylvania, Rhode Island and New York, in the order named; these four States manufacturing nearly two-thirds of the whole nation's product.

The worsted industry of the United States has grown very fast since 1870. Combing-machines are used for making worsteds, and the census returns show that the number of these in use has doubled about every eleven years, so that in 1900 there were 1451 combing-machines in the country, as against 261 in 1870. Card-wool manufacture has decreased in consequence, owing to the substitution of worsted cassimeres and coatings for woollen cassimeres, broadcloth, and the like. As a result of this change in public taste, the last census disclosed the fact that there were 117 mills standing idle, with $5,000,000 of capital invested. The manufacture of woollens, as a whole, however, showed a gain of $64,000,000 in capitalization between 1890 and 1900.

The census figures throw considerable light on the question of how much of our clothing is "all wool." In the manufacture of 564,000,000 pounds of woollen goods the makers reported to the government that they employed (as shown by the final averages taken) seventy per cent. of wool, seventeen per cent. of cotton, and twelve per cent. of shoddy. This shoddy is often made of mill waste, clippings, etc., and cheap animal hair of any sort. Its use is

not altogether an evil. It cannot readily be introduced in worsted goods, so that the most of it goes into card-wool, which contains on an average twenty-two per cent. of shoddy. The use of cotton and shoddy makes possible the production of certain light-weight low-cost fabrics that are in demand with the public, and which are of some advantage to those who want a good-looking suit without caring so much for its enduring qualities. It is of interest to note that the average cost of cotton-warp goods, sold as tweeds, cassimeres, doeskins, jeans, etc., in 1900 was 27.7 cents a yard, while all-wool worsted coatings, suitings and overcoatings averaged eighty cents a yard, these figures, of course, being manufacturers' costs.

The silk industry of the United States was comparatively small previous to 1880, from which time it has developed rapidly under a restrictive tariff and enterprising manufacture. In 1880 there were $19,000,000 of capital invested, and the product of that year was $41,000,000. In 1900, with a capital of $81,000,000, the product was $107,000,000 worth of silk, made up from $62,000,000 worth of material. Employment is given to 65,000 wage-earners, of whom nearly two-thirds were women and children. In 1880 we made but thirty-eight per cent. of the silk worn by Americans; in 1890 the percentage increased to fifty-five, and to-day only one-fourth of our silks are foreign made. Of this twenty-five per cent. many are silk velvets, hand-made silk laces and very light Japanese silks that are not made here, so that of standard silk goods our own manufacturers now produce probably five-sixths of what is worn here.

The principal features of silk manufacture development during recent years may be enumerated as follows:

1. The making of silk taffetas by power looms, in both black and colors. This development is to the credit of the United States, as it was first accomplished here and pushed to success before being taken up by European manufacturers. At least half the product of American silk-looms is on taffeta goods.

2. The making by American mills on Jacquard looms of fancy checks, stripes, and figured goods, formerly imported from France and Switzerland, and supplying the home market with a class of fancy makes unexcelled by the importations.

3. The taking of the home market for piece-dyed and printed silks, and of goods woven with raw-silk warps. There has been great enterprise and progress in these branches of the silk industry in the United States, and close competition with foreign manufacturers has led to the development of improved machinery and the practice of many economies in making.

France has been the world's leader in silks for many generations, and it is significant that at the Paris Exposition of 1900 American black silks took gold medals for superior weave and finish, and that warp-print silks were similarly honored. We seem now to have caught up with France in the manufacture and to be in a fair way to lead in this industry.

It is difficult to see where the manufacture of textiles can be improved. As far as woven goods are concerned, invention has surely approached close to the limit of perfection. If the future shall develop garments of paper or some construction made in a similarly cheap way, the time may come when the history of textiles will have to be rewritten; but that day has not yet dawned.

REVOLUTION IN METHODS OF GLASS-MAKING

GLASS is one of the oldest industries, having been made in Egypt as long ago as 2500 B.C. Though one of the commonest articles of civilized existence, few persons outside of the trade understand what it is made of. Strictly speaking, it is a compound of silica (sand) and at least two metallic oxides, one of which may be soda, and the other lime or lead. The most common mixture includes good, white, clear, fine sand, and what is known as soda-ash and lime.

The first glass factory in America was established at Jamestown, Va., in 1608; these works were destroyed at the Jamestown massacre in 1622. Another factory was established at Salem, Mass., in 1639, and many other small concerns made glass at different points in the country during the seventeenth and eighteenth centuries. About 1820 the business of the New England Glass Company at East Cambridge, Mass., began to assume fair commercial proportions, and they may be regarded as the real founders of the flint-glass industry in New England. The prosperity of this concern reached its height about the close of the Civil War, when they were operating five furnaces of ten pots each, giving employment to about 500 men and boys. The Bakewell concern in Pittsburg, which was established in 1808, led the trade in flint glass in that section for more than half a century. About 1860 the Western manufacturers began to cut into the business of the Eastern glass-works with what was popularly called lime-glass, being made of a bicarbonate of soda and lime in the place of the lead and pearl ash used in the East.

Pennsylvania now leads all other States in glass manufacturing, having 119 of the 355 factories of the country. Indiana comes next with 110 factories, but she is not so close to Pennsylvania as these figures would imply, owing to the great size and capacity of the works around Pittsburg. The glass output of Pennsylvania is forty-five per cent. of the country's total. Ohio was formerly a prominent State in the industry, but lost trade when the natural gas gave out there, many concerns moving to Indiana, where natural-gas facilities were often offered free as an inducement to manufacturers to locate.

The manufacture of glass in South Jersey was started in Salem County in 1775, and remains the most prominent industry of that section to-day. Inexhaustible quantities of fine sand and cheap wood for fuel favored the development of glass-making there; the wood is now gone, but the sand remains, enabling this section to hold its own fairly well against the natural-gas region, which has secured the major part of the glass-works of the country.

The greatest period of growth of the glass industry of the United States was between 1880 and 1890, when the production was nearly doubled. During the decade ending in 1900 the product increased but 37.7 per cent.

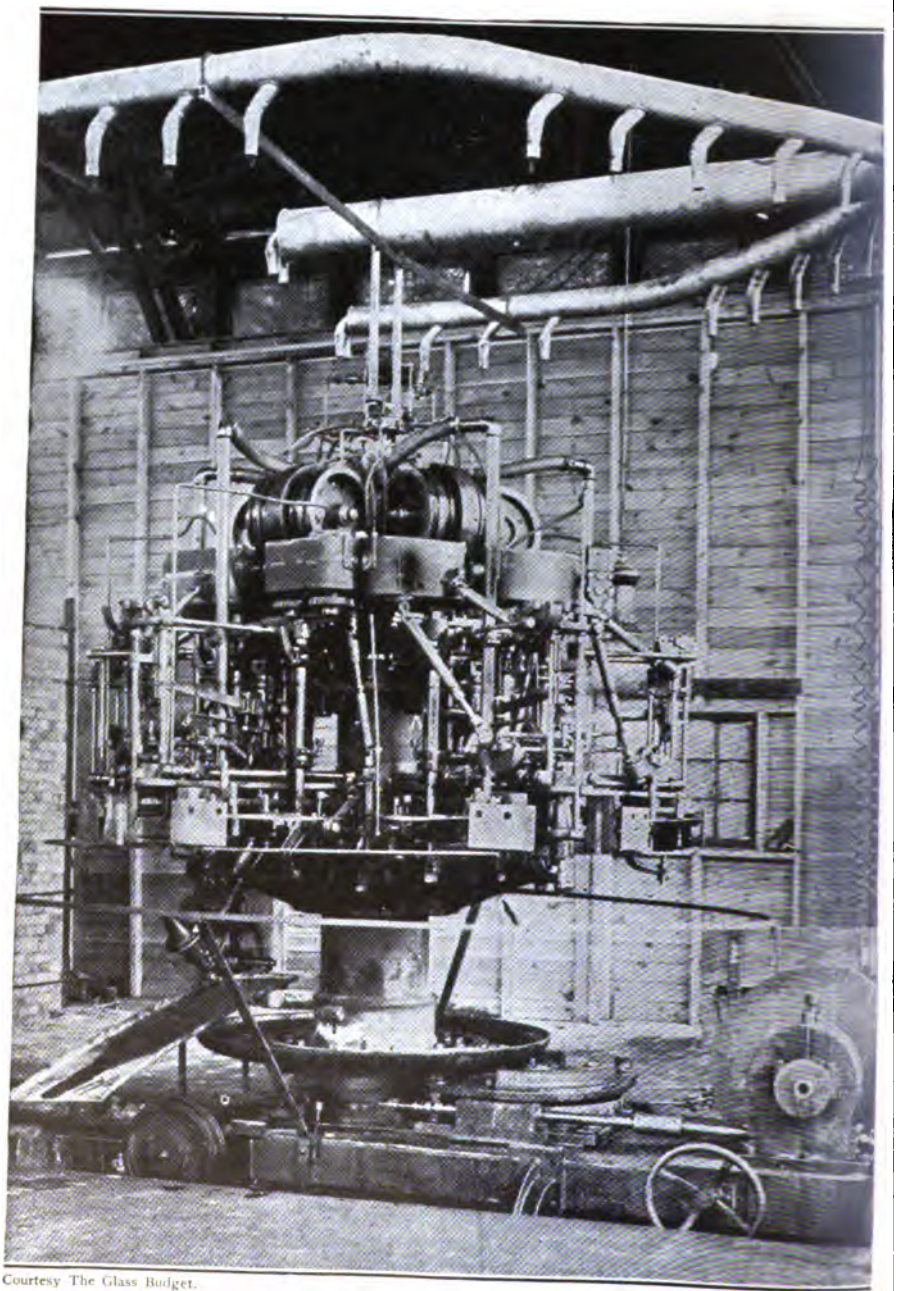
The capital invested in the glass industry of the United States in 1850 was $3,400,000, divided among ninety-four concerns; this swelled to $41,000,000 in 1890 and $61,000,000 in 1900, or an average of $172,000 per manufacturing company. The industry gave employment to less than 6000 persons fifty years ago, who received $2,000,000 annually in wages and salaries; now there are 55,000 workers in the industry, among whom $30,000,000 is annually divided. The glass made in 1850 sold for $4,641,000, and that made in 1900 for $57,000,000. The largest single item of cost, next to wages, is now the $3,200,000 annually paid by the glass factories for natural-gas fuel; soda-ash comes next, costing $2,259,000 in 1900. The total amount of soda-ash used in that year was 158,000 tons, the cost per ton being $14.32, as against $32.12 in 1890. Thus, while the manufacturers consumed sixty-three per cent. more soda-ash in the latter year, they paid for it about $800,000 less than they paid in 1890. This most satisfactory result was brought about principally through the efforts of J. B. Ford, a veteran glass manufacturer, who at the age of eighty-four years reconstructed for the second time a soda-ash factory in the endeavor to produce an American ash that would supersede the ash then imported from Europe. His success has been a great benefit to American manufacturers. Mr. Ford was also one of those instrumental in consolidating several of the Pittsburg glass-works.

Glass manufacturing is naturally divided into three classes—the window-glass trade, the plate-glass trade, and the trade in bottles and jars. The value of the window-glass made in the United States in 1900 was about $11,000,000, and the annual consumption of the country is about 5,500,000 boxes. This branch of the industry has undergone considerable change during recent years, owing to the introduction of the continuous-tank furnace instead of the pot furnace. Probably more than half the window-glass

manufacturers of the country have changed their equipment and installed the new style furnaces. It costs more than the old arrangement with pots, but the glass is produced more economically. The continuous tank is being used also in the manufacture of bottles and jars. In 1900 the census showed that there were 5000 glass pots in use and 363 continuous tanks, having about the same capacity as 5000 glass pots. The first to use the continuous-tank system was the Chambers & McKee Company, which introduced it in 1889; in 1892 they built a larger factory at New Kensington, near Pittsburg, in which are two continuous tanks, each 130 feet long. These turn out 600 boxes of single-strength window-glass every twenty-four hours.

Probably the largest flint-bottle works in the country is the establishment of Whitall, Tatum & Co., Millville, N. J., which was established in 1860. The most important improvement in the bottle trade during recent years is the manufacture of jars and wide-mouthed bottles with machines instead of blowing them by manpower, as has been the custom for many thousand years previous. It required many years of experimentation to perfect the machines for blowing jars and bottles, and it was formerly a common opinion in the glass trade that machines could never blow the glass successfully, because the work required a certain amount of human intelligence and judgment. Nevertheless, the machine conquered about 1895, and has come into use for wide-mouthed articles, though it cannot be used for narrow-necked bottles. The old-time glass-blower, with the puffy cheeks and the gathering rod, is losing his occupation. The new bottle-blowing mechanism is thus described by Shirley P. Austin, expert special agent of the United States Census Bureau, in a special bulletin issued concerning the glass industry:

"In 1896 an American combined the consolidated mould and rotary table. On a rotary table is placed a series of fine separate, duplicate, double moulds, each mould containing an outer blow-section, having a ring integral with it in which the neck of the article is pressed, and a telescopic press-section rising within the blow-section and receiving the glass, forming, with the neck of the blow-section, a press-mould. The glass is dropped into the combined mould when in this press-mould position, and the table rotated, bringing the mould under the plunger, which enters it and presses the neck and wind-cavity into the dependent mass of glass. The plunger is withdrawn, and another rotation of the table brings the mould under the blow-stem, the telescopic press section of the combined mould having dropped in the mean time, exposing the glass-blank within the blow-section. The bottom plate is inserted and the air admitted to expand the glass-blank to the form of the blow-mould. The next rotation of the table brings the mould to where it is opened by a boy and the finished article is taken out and removed to the annealing oven."



Courtesy The Glass Budget.

Glass-Bottle-Making Machine.

The gain in making bottles by machine instead of employing a man to do the blowing is very much greater than the saving of the man's time and exertion. The blowing-machine has already reached a point where it is no longer a matter of saving one man's labor, the latest mechanism aiming to make four to eight bottles at one time. This must result soon in great increase in the capacity of bottle factories. There is practically no limit to production, as the great tank furnaces can furnish hundreds of tons of glass within the hours of a working-day. The more machines a factory puts in the more bottles it can turn out, whereas under old methods only a limited number of blowers could work around a furnace.

The manufacture of plate-glass in America was largely experimental up to about 1875; in 1880 there were three factories in the country, the most important being the American Plate Glass Company, of Crystal City, Mo., which began business in 1872, carrying the new industry to a most successful issue. The American product of plate-glass is now valued at between $6,000,000 and $7,000,000 annually. The principal improvement introduced in plate-glass manufacturing in American practice is the annealing lehr, of which 1350 were in use in the census year of 1900. This lehr is built about 200 feet in length, starting from the casting-table as a continuous series of five kilns, and then continuing in the form of the usual rod lehr, as used in window-glass factories. These five stations rest at the outset on a solid clay hearth; they are electrically lighted and the different degrees of heat are readily maintained. The plate enters the first station in a molten condition, but is set before it passes out of the fifth station to the rod lehrs. An annealing lehr such as that described, of ninety-six pot capacity, costs about $20,000, so that less cost and less space are involved with these lehrs than with the old kiln system.

In the process of grinding plate-glass there is now used a patent table for reducing the temperature. This is accomplished by a circulation of water under the table during the process of grinding, and because this keeps down the heat the grinding and polishing can be done at much higher speed. It was formerly necessary to turn the glass after grinding on one side and grind the other side before doing any polishing. The use of the new transfer-table permits the entire grinding and polishing of one side of the plate-glass before operating on the other side. This saves much time, as only one turning of the glass is now necessary, and turning is a tedious process because the glass has to be carefully set in a bed of plaster.

The polished bevel-plate mirror is no longer very costly, but

finds its way into the homes of people of modest means. Rough or corrugated plate-glass, often colored and known as cathedral glass, is sold at a very moderate figure, and used in door and window openings where it is desired to admit light but obstruct vision.

What is known as cut glass is the most costly product in this field of industry. The imitation is made by pressing or forming

Courtesy Popular Mechanics.

Glass-Cutting.

in a mould, but the real cut glass is produced by cutting and polishing wheels driven under the direction of an expert operator. Pitchers, bowls, carafes, goblets, and a variety of glass articles for the dining-table or dressing-table are made of cut glass. The dish is first moulded in the same manner as a cheap glass dish, and a number of lines are then marked on the glass with either resin, red lead, or the like, these serving to guide the eye of the cutter, who

usually forms a pattern without other assistance, although very intricate patterns are sometimes scratched on the glass. The first wheels used for cutting are termed roughing-wheels, and are made of wrought iron or copper. The cutter holds the dish against the wheel, using moistened sand to assist the cutting, and water to keep the work cool. Several forms of wheels are used, the most common being mitre-wheels, with which the favorite diamond pattern is produced. At the end of this cutting the glass appears dull and lustreless, and requires to be polished with wheels made of a special stone, or of wood or felt. In this polishing process powdered putty is used to assist the work. With these simple tools the expert glass-cutter produces the prismy surfaces so much admired in cut glass, and which give it an iridescence second only to that of the diamond.

TENDENCY OF MODERN ARCHITECTURE

ARCHITECTURE is the oldest of human avocations. The lake-dwellers and cave-dwellers built roofs and wind-shields as well as floors before they learned how to weave clothing. As men became more skilled, they built huts, then stone castles, and finally houses, palaces, churches, etc. The architects of the Middle Ages, whose taste gave us the five orders of architecture—Greek, Roman, Corinthian, Doric and Gothic—built mainly in stone. The multiplicity of modern materials defies all restraints as to orders or architectural rules, and we see buildings composed of features belonging to any or all of the known orders, with all sorts of additions and variations developed by modern needs or constructive ingenuity.

The man who designs buildings is called an architect, but modern structures involve so many ramifications that no one man can master them all, any more than one man could erect all the large buildings in a great city. There are architects who make a business of designing steel office buildings; others who design factories, mills, electric plants, etc.; others who confine themselves to brick and stone construction, as of rows of city dwellings, flat-houses, and apartment-houses; others who find a field of work in designing detached residences, which are mainly of wood; and there are some who have been able to secure a line of work in designing dwellings for the rich, which would be called palaces in almost any other country than America. There are so many kinds and classes of buildings, and the modern architect has so many kinds of materials to use, that it is no longer possible to classify the work according to the historic orders. The buyer of a fine dwelling nowadays is satisfied when it meets his ideas of beauty, arrangement, size, and price, without asking whether it is Corinthian, or Venetian, or Composite, or Colonial.

Building construction in the United States during the first half of the nineteenth century showed very little originality, the work of native architects being largely copies of English designs. There has been developed in the Eastern States the style that has come to be known as Colonial—a style that is easily recognized, but hard to describe, and which seems to have grown out of the ability of the architects to secure shingles easier than other building material. It may be said that architecture was taken up seriously in the United

Fisher's Building, Chicago.

States about 1856, that being the date of the organization of the American Institute of Architects. This organization has certainly exercised a most valuable influence in the direction of more sightly buildings, as well as practical constructions for commercial purposes. This influence has made itself felt mainly in diversity, an effort being made to avoid the dreary uniformity that comes from building row after row of houses on the same plan, especially in crowded cities, where there is a tendency to build structures straight to the street line, and of a uniform height, with very little variation in appearance. The architect has fought against the commercial

Dufferin Gate, Quebec.

instinct that sometimes prompted this uniformity, and in the newly-built sections of our large cities the diversity is more marked to-day than it ever was. A conspicuous illustration of a successful effort to keep away from the tedious repetition of old styles was observed in the rebuilding of that part of Boston destroyed by the great fire of 1872, where the new buildings were in marked contrast to the older and less sightly structures built in seemingly endless repetition.

The Capitol at Washington was the first effort of any importance in America to construct a pretentious building. It was begun in 1793, and, owing to numerous stoppages of the work, was not completed till seventy-two years later. Its modern construction

really dates from 1861, when it was redesigned, and the work carried out with some system. While it is a large and imposing building, it has been subjected to severe criticism by many prominent architects, and doubtless it is very faulty from a twentieth-century point of view. The white marble of the wing is from Lee, Massachusetts, and the red sandstone of the main building of local origin. I say red, although it has so long been painted white that most people are unaware of the nature of the material. The dome is of cast iron, painted white to match the stonework, and, considering the little advance that had been made in iron construction at that date, it is a very creditable affair.

New York Stock Exchange, Interior.

The government at Washington has maintained salaried architects to design and supervise the public buildings for the past seventy-five years, but their work has been so handicapped by political influences that they have never done anything noteworthy.

It has been estimated that there are about 13,000,000 buildings or houses in the United States, and that 12,000,000 of these are built of wood, indicating how completely wood dominates in building construction. The wooden house is the house for the million, the stone or steel construction being for the few who have means to build better. Wood also enters very largely into the interior work of all classes of buildings. The great progress made by the

planing-mills in producing wood mouldings by machinery, and also special machines for forming all the standard sizes and shapes of wood that are used in dwellings, has both cheapened and improved the material that goes into our houses. Another great advance has come from the introduction and general use of ready mixed paints. through which it is possible to obtain at any time any convenient quantity of given colors with an assurance that the colors will always be uniform. The substitution of wire-cloth, often called wire-lath, for wood-lath is steadily increasing, adding to the strength and durability of interior walls and partitions, as well as reducing the

Museum of Art, St. Louis, Missouri.

liability to fire. The wire-cloth holds the plaster of a wall often better than the wooden lath, and is more easily and quickly nailed to the scantling.

It is not many years since all brick houses were of the dull red color which has become so unpleasantly familiar, and the introduction and constantly increasing use of light-colored brick has been a real artistic boon everywhere, tending to relieve the gloomy monotony of rows and rows of red brick houses. The increased use of terra-cotta has also tended to diversify the appearance of dwelling-houses.

During the past twenty-five years American-made plate-glass and American marbles have continuously increased in use in the

buildings of the country, having practically driven out the foreign products. The beautifully variegated marbles of Tennessee and the purple slates of Vermont have been combined with hard polished woods and plate-glass mirrors in countless forms of mantels and fireplaces for beautifying interiors.

Sheet-iron cornices for the top fronts, especially of business buildings, have come into most extended use, adding greatly to the appearance at small cost. Sheet-steel ceilings are also manufactured, having obvious merits; skylights are now commonly made with iron frames, instead of the old pattern of clumsy wooden frames, with the result that they hold the glass much more positively and are less subject to leakage.

East Entrance, Capitol at Washington, D. C.

While no buildings are wholly fireproof, in the broadest sense of the word, yet the modern buildings of steel, concrete, stone, brick, and glass are a close approach to the desired object. What is known as the flat arch, used in forming the ceilings in these buildings, has more to do with checking the progress of a fire than any other one feature of construction. The steel ceiling beams are in section the form of an I. Advantage is taken of the little ledges at the lower edge of the beams to support the flattened arch, usually made of terra-cotta, giving considerable supporting strength, and at the same time cutting off flames, which might burn through almost any other form of ceiling. Since the Baltimore fire of 1903 architects are preferring concrete to terra-cotta for flat arches and other uses.

The modern builder and constructor has very much improved means of handling the material used in putting up a building. We now seldom see the hod-carrier going up a line of ladders with a hod of mortar or bricks on his shoulder; instead there are portable elevators for hoisting the material to the place where it is wanted, and derricks and hoists of all sorts are used for saving manual labor. In the construction of the larger buildings erecting plants are employed, so that everything is handled very much as it would

Flat-Iron Building, Broadway and Fifth Avenue, New York City.

be in a large manufacturing works with the least expenditure of effort and time.

A feature of modern American building construction is the increased use of Portland cement usually in connection with steel. The price of cement has been gradually reduced for a number of years until it has become generally cheaper than stone construction, and in many cases cheaper than brick, while if well made it is quite as good as the best stone. Portland cement for building purposes is composed of one part cement, three parts of sand, and five parts

of broken stone; this is very suitable for protecting steel construction and filling in the spaces between pillars and girders. The cement can be laid directly on the steel; if the latter has been previously cleaned, it does not even require to be painted. The combination of steel and cement is very desirable from the point of view of insurance against fire, and when generally employed will materially reduce insurance rates. Floor-beams and joists made of cement in the form of hollow tubes enclosing steel braces are a new article of manufacture likely to come into general use.

Slag cement is also coming into increased use, there being nine plants manufacturing it in the United States in 1901. Slag is a

State House, Boston, Massachusetts.

product of the blast-furnace, resulting from a mixture of limestone and iron ore. It is of no value to the iron manufacturer, and vast piles of it are accumulated near the blast-furnaces. When this slag is suddenly cooled, then dried, and mixed with one-fourth part of slaked lime, it makes a fine material for cement. The slag is also made into brick, which can be made much harder and stronger than the ordinary clay brick. Germany appears to be ahead of America in recognizing the advantages of slag-cement and slag-bricks, having established manufactories before we did.

The construction of steel buildings began to attract attention in New York City about 1890, at which date a few large steel struc-

tures had been erected and promised to be commercially successful. The primary idea in constructing a large and tall business building of steel was to secure a higher rental from a valuable space of ground than could be secured from a brick or stone building, whose natural limit is about six or seven stories. After a few of these tall business buildings had been erected, it became evident that they had other advantages than height and increased floor-space. Tenants crowded into them and were willing to pay a higher price for offices than they would pay in brick buildings. They liked the

Interior of Library, University of Pennsylvania.

appearance of the structures, and the increased light and air obtained, and also found a benefit in being under the same roof with a large number of other concerns. In a big business building a tenant can always find a telegraph office, public telephone station, stationery store, barber-shop, typewriting bureau, and often a restaurant, besides a mail-tube and many other small conveniences.

The steel used in these big business buildings is what is known as mild structural steel, and is rolled in the mills in the form of I-beams, L's, Z's, etc., these being punched with holes and riveted together to form the skeleton of the building. All the steel parts are made to size at the mills, the contractor and builder having

simply to put them together. This is done with an erecting plant, having stout cranes and hoisting machines for carrying the steel beams to the positions where they are to be riveted together. As the frame goes up, the erecting plant is carried up with it to the topmost story. After the steel-work is well started, stone, brick, terra-cotta, or cement is used to protect the steel from the weather. The lower floors of a building are often covered on the outside with stone, thus presenting the appearance of a stone building; a little higher up brick or terra-cotta is employed, resting on the stone up to about the sixth story; above that point the brick-work is sup-

Plymouth Congregational Church, Cincinnati, Ohio.

ported by the steel structure. Portland cement is used largely in the foundations and floors of these buildings.

One of the first considerations in erecting one of these gigantic steel towers is the securing of a foundation that will bear the enormous weight without danger of shifting or settling. In New York City the foundations are usually carried down to the bed-rock that underlies Manhattan Island, but in cities like Chicago, erected on a sandy soil, it is often necessary to make an artificial base that is sufficiently substantial for the purpose. One method is to sink a mass of steel rails in a bed of concrete or cement, and by laying the rails so that they cross, secure a very solid base; in other cases the method is simply to dig down a considerable distance and build

stone or brick piers, filled in with cement, so that when this hardens there is practically one great block of stone.

Ingenious methods are resorted to for distributing the weight of the heavy walls and interior supports so that no portion of the foundation shall be unduly loaded. The gas, water, and other pipes for the supply of the steel building are carried up in the open spaces formed in the columns. The plumbing and wiring of a great building is a complicated work in itself, and has to be carried on under

General Grant's Tomb, Riverside Drive, New York.

the rules and restrictions laid down by the cities in which the building is erected.

The work of the engineer in designing one of these great buildings has become very complex. It is necessary to design the top story first and work downward, each story being supplied with beams of a proper strength to sustain the weight above it. If a designer should undertake to begin at the base of a large building, he could only guess at the weight to be carried, and after he had worked up to the top he would have to go back again and revise and correct every part carrying weight.

The protection of steel structures from corrosion or loss of

strength by rusting has attracted a considerable amount of attention, and there have been conflicting claims that these buildings would never wear out, or that within a few years some of them would be in a dangerous condition. The time since their erection was begun has been too brief to form a full idea as to what may be expected of them in the way of durability, but it is probable that they will last until the demands of future generations shall cause them to be torn

Hotel Waldorf-Astoria.

down to make way for bigger and better structures. It is common to protect the iron with a coat of paint or some kind of patent composition based on graphite, rubber, red lead, or the like. The investigations thus far made by engineers and others interested go to show that a mixture of lead, graphite, and oil affords the best protection against the rusting of the steel, and when the metal is properly enclosed and protected from the weather there is little opportunity for moisture to work in and start the work of corrosion.

The indications are that the buildings of the future will include more steel and cement and less wood. Cement is cheap and getting cheaper, and Edison and others have established enormous plants for its manufacture. When cement gets down to five dollars a ton, the best way to build a dwelling-house will be to make rough wooden moulds and cast the walls of solid cement. Thus a stone house can be made at the price of a wooden one. A good many cement dwellings are being built now, and they are sightly as well as sensible and satisfactory. The total production of manufactured and natural hydraulic cement in the United States is now 3,500,000 tons a year,

Supreme Court Building, Appellate Division.
Madison Avenue and Twenty-fifth Street, New York City.

and the quantity is likely to increase very largely, as the manufacturers seek to lower the cost in order to increase the demand.

The making of slag cement was taken up in earnest in the United States in 1902 and 1903, several large plants being established in Pennsylvania. Probably nowhere in the world are the conditions better for the manufacture, as the raw materials are both plentiful and cheap. The refuse of the blast-furnace supplies the slag, and limestone is easily obtained. New Jersey is the second State in the industry, the Edison works being among the largest in the world. Michigan, New York and Indiana are also making

increased quantities of Portland cement. The gyratory crusher is commonly employed to break up the rock, but the Edison works

Courtesy The Iron Age.

150-Ton Rotary Cement Kiln at Edison Portland Cement Company's Works.

employ what they term "giant" rolls, that have enormous crushing capacity, as may be judged from the illustrations. The manufac-

tured cement is usually shipped in barrels of 400 pounds, and as the wholesale price varies between one and two dollars a barrel, it is apparent that it is the cheapest building material we have.

Courtesy The Iron Age.

Giant Rolls for Breaking Rock in Manufacture of Portland Cement.

The natural rock, Portland and slag cements all have the quality of hardening under water, which makes their use almost mandatory for foundations at all liable to flooding. A "sky-scraper" of twelve stories was erected in Pittsburg recently which was almost wholly of cement braced with steel. If this is the success that it appears, such buildings will become common.

FLOUR-MILLING BY MODERN MACHINERY

About 1820 the Genessee Valley in New York State was the leading centre of the wheat-growing and flour-milling industry of the United States. The Rochester mills became famous, holding a leading position for at least half a century, Rochester being known as the Flour City until about twenty years ago, when the waning of the milling industry there and the growth of the nursery business caused the name to be changed to Flower City. As the wheat farms extended farther and farther to the west, the milling industry followed, and by 1840 the States of Ohio, Kentucky, Illinois and Michigan were producing thirty per cent. of the country's total of flour. By 1860 the States west of the Mississippi River produced about half of the total wheat and flour. Milwaukee was a prominent flour manufacturing city during the sixties, but by 1870 Minneapolis began to assume a prominent position in the milling trade, and to-day she is the largest manufacturer of flour of any city in the world, doing the milling for the vast wheat districts of Minnesota and North and South Dakotas.

The enormous demand made upon the mills of Minneapolis during the past generation may be gathered from the figures of wheat raising in that vicinity: in 1870 the Minnesota wheat crop was 18,000,000 bushels, and in 1880 the wheat crop of the two Dakotas was 3,000,000; but in 1894 the wheat crop of Minnesota had grown to over 60,000,000 bushels and that of the Dakotas to 100,000,000 bushels, while at the present date the average crop of these States is probably 175,000,000 bushels annually, of which two-thirds is milled at Minneapolis.

In 1900 there were 25,000 flour-mills in the United States, as against 18,000 in 1890, but the vast majority of these mills are small concerns, there being but 135 mills in the country that produce 100,000 barrels or more a year. Of these large mills Minnesota has 24, New York 14, Kansas 13, Illinois 12, Missouri 9, and no other State has more than 6. The total capital invested in the milling business was in 1900 $219,000,000, an increase of five per cent. only over the capital invested in 1890. The number of wage-earners, which was 63,000 in 1890, shrank to 43,000 in 1900, owing to the introduction of improved machinery, the mill-owners saving $4,000,000 a year in wages and salaries because of the reduction.

The value of the product of these mills in 1900 was $561,000,000. The statistics of milling show that while the corn crop of the country is very much larger than the wheat crop, most of the corn is fed to cattle, and that the public consumes twice as much wheat as corn, and four and a half times as much wheat as oats and other cereals.

The making of good bread is impossible without good flour, and American flour is the best in the world. If it be true that we are a nation of dyspeptics, as has been asserted, the fault is not with the flour-mill. There science goes hand in hand with mercantile

Circular Tile Grain Elevators, Minneapolis.

enterprise, and the great millers of the Minneapolis territory give us a flour made from the hard grain of the northwest wheat region that is unsurpassed in nutritive quality, that is purified and divided in a manner second to no other, and which is produced at a cost probably a little lower than anywhere else.

The *Scientific American* says in a recent article:

"The wheat grain is peculiar, and is more complex than is generally supposed. Its outer hull or cellulosic coat is composed of five layers, and beginning with the outside is known as the epidermis, epicarp, endocarp, testa, and inner coat of bran. Leaving these botanical considerations to the botanist, the miller takes upon himself the entire separation of these coats from the inner starch and gluten-producing cells inclosed. The 'germ' is useful as a breakfast food, but not for milling, as it impairs the keeping qualities of the flour. Besides the starch cells there are gliadin and glutenin cells; the latter two when combined

with water form gluten, which gives the flour much of its value as a food. The milling processes must now remove the bran coats and crush the gluten and starch to a soft powder of great fineness, and this is only accomplished by a series of operations which are interdependent. At this point, however, it might be well to call attention to a popular error. Flour is not dust or pulverized wheat; it really consists of *sharp* granules of uniform size, composed of starch and gluten, all impurities having been removed. The thought might arise as to what is known as 'whole wheat' flour, which created such widespread interest a few years ago, on account of its alleged great nutritive value over white or 'patent' flour. It is perfectly true that the germ and bran have food value, and if the human stomach were capable of performing all the operations of the miller, this

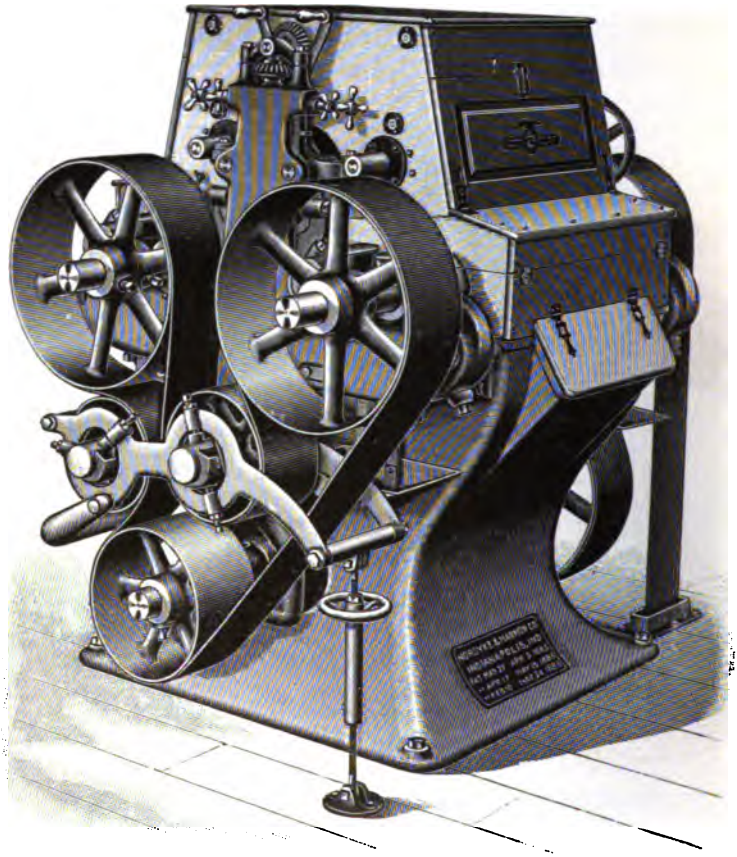
Courtesy Scientific American.

1600-Bushel Grain Scales.

could be utilized. There is more nutriment in the skin of the potato than in the body of it, but who can eat an equal weight of the former without the stomach's rebelling? A nutritive substance is not always a digestive one. We give flour to men and women and bran to cattle, and all thrive, but a man is no stronger than his stomach. Milling is not done to make a white flour, but to make a food product which will be easily assimilated."

The introduction of modern machinery into the flour-mills of the United States may be said to have begun in 1868, when E. N. La Croix, of Faribault, Minn., built the first American middlings purifier, and began marketing the flour, which sold at an advance of fifty cents a barrel. George T. Smith improved upon this puri-

fier and took out a patent, and before long the increased profits on flour handled with this machinery amounted to three dollars a barrel. This opened the eyes of Minneapolis millers, and C. A. Pillsbury and George H. Christian and others went to Europe to study the Hungarian method of milling, which had the reputation of being the best in the world. On its return, this commission recommended

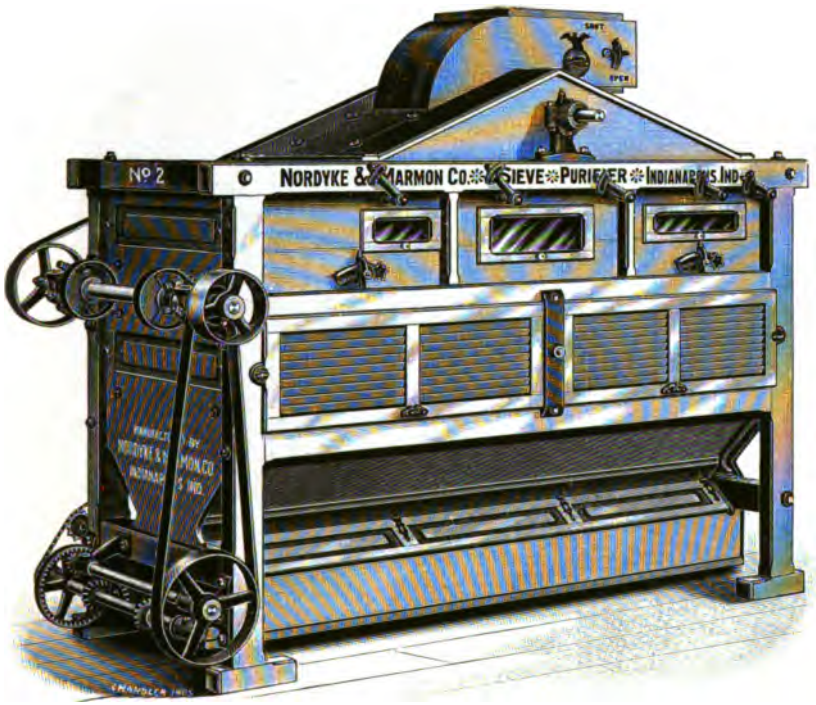


A Roller-Mill.

the adoption of the Hungarian system, especially the substitution of rollers for millstones. Some of the American mills built machinery patterned after the Hungarian, but the Pillsbury mills Americanized the machinery and simplified it. Rollers of chilled iron and porcelain gradually replaced the millstones, the change greatly improving the character of the flour, and saving much more of the gluten. Under the old system of milling or crushing the

wheat between upper and lower rotating millstones, the miller tried to get flour as soon as he could and as fast as he could from the broken product, but with the roller system the miller does not try to get flour at the first two or three breakings, but simply tries to divide the product scientifically, so that at the last passages through the rollers he may obtain a more perfect separation.

Among standard makes of roller-mills, the style C mill of the Nordyke & Marmon Company, here illustrated, is widely used. In



A Middlings Purifier.

all these mills there are clever devices for exact adjustment of the rolls, and coil springs are arranged to hold the rolls apart so that they may not touch each other, and also to allow the rolls to spread in order that they may not break should any hard substance by accident come between them. There are two pairs of corrugated rolls, the first pair rotating slowly, the other more rapidly. The opposed rolls turn in opposite directions so as to break the kernels.

After the roller-mill comes the scalper, which has a flat sieve that allows the middlings or granular material to pass through, while

the coarser grains pass over the scalper to another set of rolls for further grinding. About five grindings and scalpings are required.

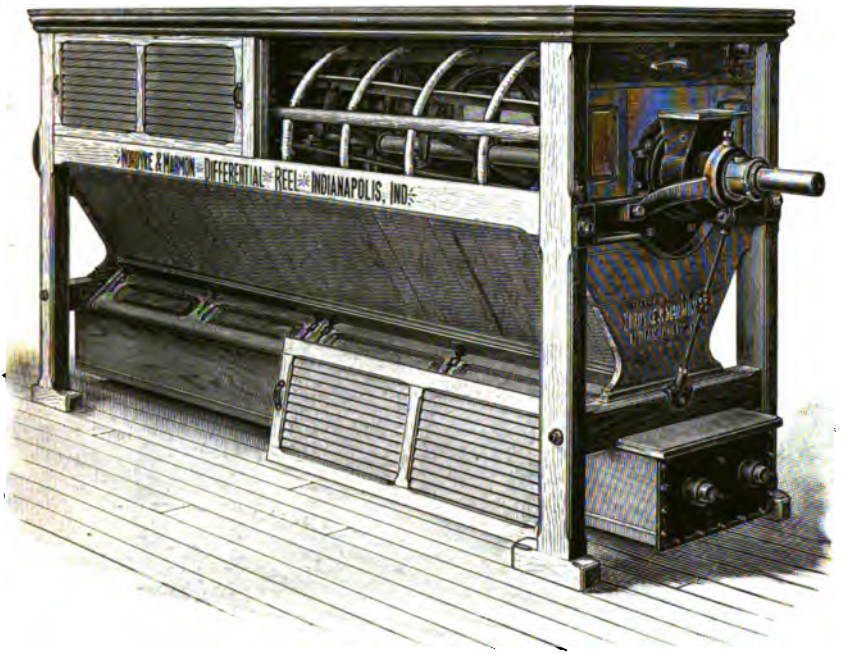
The square sifter here shown is a gyratory sieve bolter of large capacity, but designed to use little floor-space. Swing sifters or scalpers are also manufactured for doing similar work. The middlings purifier has been manufactured in a great many forms and been subjected to numerous improvements. The one chosen for illustration here is the standard sieve purifier, which is largely used. The sieve-frame has removable cloth strips, so arranged that the sieve may be tightened with thumb-nuts. A brush underneath ex-

Square Flour-Sifter.

tends the full length of the sieve, travelling automatically from side to side, and keeping the silk clean. At the top is a fan, and the suction-chamber extends over the entire sieve; there are valves adjustable from the outside to control the air-currents. The door-slats deflect the incoming air downward, thus avoiding annoyance from strong drafts. The bran, being lighter than the rest of the middlings, is separated by the fan, and discharged into a separate compartment. Treatment in a second purifier follows. The introduction of the middlings purifier created many changes in milling practice.

The differential reel, round reel, hexagonal reel, octagon reel,

and flour-blender are names given to varying forms of machines for dressing, scalping, mixing, blending, and similar operations. The differential reel here shown has a central feed-tube and an open-tail discharge, there being a conveyor-screw on the operating shaft. This reel has a frame or outer cylinder covered with bolting-cloth, rotating at a slow speed, and a series of blades rotating within, near the cloth, at a higher speed. These blades spray the flour evenly over the interior of the cloth-cylinder, the difference in velocity insuring free and rapid bolting.

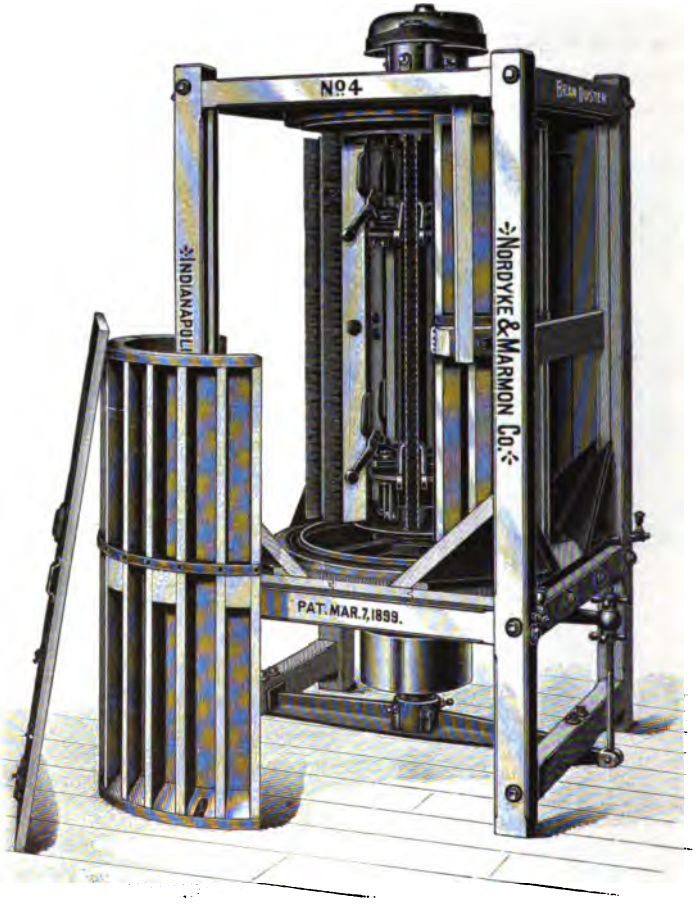


Nordyke & Marmon's Differential Reel for Dressing Flour.

Among many forms of dusters the upright bran-duster has been selected for illustration. It has a straight cylinder and brushes that are adjustable while running. The flour stock in this machine is kept very evenly distributed, avoiding all bunching in material. The bran is spouted in at the top of the machine and falls on a disk attached to a spindle that distributes it evenly against a wire cloth. Sweeps at the bottom discharge the flour through one opening while the bran is discharged through another opening below the case.

A conspicuous feature of the milling industry is the storage

of the grain, which accumulates and has to be cared for in enormous elevators. As the crop is harvested within a few weeks, provision has to be made for storing the whole of the year's product, which means for the whole country perhaps 500,000,000 bushels of wheat. The average wheat farmer of Dakota sends the bulk of



Upright Bran-Duster.

his grain to what are termed railroad elevators located in the nearest large town. From such elevators the grain is transferred to larger storage elevators located at transfer points, as at the junction of a railway with a line of steamers. The tendency of grain elevators has been steadily towards increased size. In 1890 there were only a few of a capacity of 1,000,000 bushels, but to-day there are at the more important railway terminals and harbors grain elevators

having a storage capacity of from 1,500,000 to 3,000,000 bushels. The elevator of the Great Northern Railroad Company at West Superior, Wisconsin, is credited with a capacity of a little over 3,000,000 bushels, being designed for containing both corn, wheat, and oats.

The latest pattern of grain elevator is made up of a group of large cylindrical tanks, formed of sheet steel resting on stone foundations, and protected with outer walls of brick or cement. Above the tanks is a superstructure for carrying the hoisting and conveying machinery, that handles the grain as it is brought in and taken out. The plan of construction in common use is to locate the distributing department next to the bins and above the scale-room; above this being what are known as the cleaning garners, and above this the shafting and other transmitting machinery. When the grain comes in it is carried to the top of the building by conveyors, which usually consist of endless belts carrying buckets. The dust is removed by nicely regulated air-currents and conveyed out of the building, while the grain is distributed to the proper bins after weighing. When a bin is full, the weight is registered automatically, and a door opens in the bottom of the bin, allowing the grain to fall into one of the large storage compartments.

The grain is taken out of the bottom of the storage tanks through large spouts, which can be emptied directly into the hold of a vessel, so that no manual labor whatever is required in handling the grain.

Sometimes it is necessary to locate a large grain elevator at some distance from a water front, a case in point being one of the elevators of the Illinois Central Railroad Company, at New Orleans, which is located near the tracks, but is 500 feet from the river into which it delivers its grain. By means of a system of belt-conveyors the grain is carried to the water and deposited in the vessels at a rapid rate, it being practicable to load several vessels at once. At this elevator the grain is unloaded from the cars by automatic steam-shovels, which are run into the elevator building on depressed tracks.

The Pillsbury and Washburn mills of Minneapolis are the largest in the world, and the twenty-odd mills of that city have a daily capacity of over 30,000 barrels of flour. The Minneapolis flour output for 1903 was nearly 16,000,000 barrels, being 600,000 less than in 1902, owing to a strike. The export trade of Minneapolis reached its maximum in 1900, when 5,702,000 barrels were sent abroad. During recent years the United Kingdom has bought less, owing to discriminating legislation as to freight rates. The

foreign trade of Minneapolis would have suffered severely were it not that the trade with the Orient began to increase at the time that the English demand lessened. The flour output and direct exports of Minneapolis mills by calendar years are shown below:

	Output, Bbls.	Exports, Bbls.	Per Cent. Exported.
1903	15,643,750	3,100,165	19.80
1902	16,260,105	3,410,405	20.97
1901	15,921,880	3,897,905	21.31
1900	15,082,725	5,702,485	37.80
1899	14 291,780	4,009,135	28.05
1898	14,232,595	4,052,585	28.47
1897	13,635,205	3,942,630	29.13
1896	12,874,890	3,717,265	28.80
1895	10,581,635	3,080,935	29.11
1894	9,400,535	2,370,756	25.21
1893	9,377,635	2,877,275	30.68
1892	9,750,470	3,337,205	34.22
1891	7,877,947	3,038,065	38.53
1890	6,988,830	2,107,125	30.14
1889	6,088,865	1,953,815	32.08
1888	7,056,680	2,197,540	31.14
1887	6,574,900	2,650,000	40.30
1886	6,168,000	2,288,500	37.10
1885	5,221,245	1,834,845	35.13
1884	5,317,670	1,805,875	33.22
1883	4,046,220	1,343,105	33.96

THE LEATHER AND SHOE TRADES

THE tanning and preparation of leather dates from the earliest period of human history; the Egyptians tanned leather under the early Pharaohs, and the art was known to the ancient Mexicans and Peruvians, as well as to the Chinese. Roughly speaking, tanning consists in scraping an animal's hide clean, and then soaking it in an astringent acid, usually tannic acid, as that made from oak- or hemlock-bark. This acid acts chemically on the gelatin and gluten of the hide, causing them to form insoluble compounds. In modern practice the business is divided into curing and tanning, the former name being applied to those cleaning processes adopted before soaking the hides.

Vaughn Leather-Glazing Machine.

The tanner speaks of the skins of all large animals, as cattle, horses, elephants, hippopotami, etc., as hides; the skins of small or yearling cattle he terms kips; while the word skins is reserved for the covering of all the smaller animals, as sheep, goats, calves, deer, pigs, seals, etc.

Tanning was one of the earliest industries undertaken in America, forty-one of the early settlers of Massachusetts Bay being tanners by trade. They were favored by circumstances in following their calling, as skins and hides were very cheaply obtained in those days when wild game was abundant and tan-bark was ob-

tained with little labor. They not only at once supplied all the demands of the American settlements for leather, but about 1800 had begun to export to England. The first record of tanneries in the United States locates one in Virginia in 1629 or 1630, and one in Swampscott, Massachusetts, in 1630. The latter was established by Francis Ingalls, and was run successfully for a great many years, the vats remaining in existence until 1825, when they were filled up because the land was wanted for other purposes.

A man named Mitchell started a tannery at Joppa, near Bridgewater, Massachusetts, probably in 1630, and a few years later John Glover started one at Dorcester. In 1647 there were a number of tanneries at Roxbury, which became known as a tanning centre.

After the Revolutionary War, the tannery of Colonel William Edwards was one of the leading industries of New Hampshire; he

Automatic Bleaching-Machine.

developed improved machinery and shipped leather regularly to Boston after 1794. The Hampshire Leather Manufacturing Company, of Massachusetts, which was established in 1809 with a capital of $100,000, purchased Edwards's tannery and others in Northampton, Chester, and Cunnington, securing something like a monopoly of New England trade, and being perhaps the first instance of an American "trust." This concern had a producing capacity of 16,000 large hides a year, and did a successful business for a long time.

The United States census of 1810 gives the total manufacture of leather in the country as of $18,000,000 value, though historians of the leather industry agree that it was at least $20,000,000. By 1850 the industry had grown so that the output amounted to $43,000,000. The following table affords a summary of the growth of the leather trade during the last half-century, from which it appears that the development of the industry was practically continuous.

	Year.	Number of Establishments.	Capital.	Wage-Earners.		Value of Products.
				Average Number	Total Wages.	
Total	1900	40,751	$356,581,838	251,920	$105,571,004	$615,720,395
Boots and shoes, factory product	1900	1,600	101,795,233	142,922	59,175,883	261,028,580
Leather, tanned, curried, and finished	1900	1,306	173,977,421	52,109	22,591,091	204,038,127
Saddlery and harness	1900	12,934	43,354,136	24,123	10,725,647	62,630,902
Leather goods, pocket-books, trunks, and valises	1900	772	13,505,819	14,990	5,679,767	26,905,814
Boots and shoes, custom work and repairing	1900	23,560	9,262,134	0,698	4,128,361	26,550,678
Boot and shoe cut stock	1900	342	7,003,080	6,155	2,230,691	23,242,892
Belting and hose, leather	1900	105	7,410,219	1,667	913,937	10,623,177
Boot and shoe uppers	1900	132	273,796	256	125,627	700,225
Total	1890	33,970	265,687,684	233,496	107,978,195	529,311,269
Boots and shoes, factory product	1890	2,082	95,282,311	133,690	60,667,145	220,649,358
Leather, tanned, curried, and finished	1890	1,749	97,653,898	42,095	21,090,176	171,063,317
Saddlery and harness	1890	7,931	35,346,620	22,672	10,908,918	52,970,801
Leather goods, pocket-books, trunks, and valises	1890	613	11,148,694	10,074	4,448,796	18,814,885
Boots and shoes, custom work and repairing	1890	20,803	14,230,081	16,981	7,422,377	34,856,551
Boot and shoe cut stock	1890	344	5,401,834	4,992	1,891,031	17,903,846
Belting and hose, leather	1890	93	4,973,420	1,342	780,615	8,633,634
Boot and shoe uppers	1890	317	1,216,026	1,353	609,324	3,346,002
Leather, dressed skins	1890	38	434,800	297	159,813	1,072,755
Total	1880	32,327	152,380,350	207,096	79,747,644	461,189,543
Boots and shoes, factory product	1880	1,959	42,994,028	111,152	43,001,438	166,050,354
Leather, tanned, curried, and finished	1880	5,426	67,117,674	34,887	14,062,456	184,865,633
Saddlery and harness	1880	7,999	16,508,019	21,446	7,997,752	38,081,643
Leather goods, pocket-books, trunks, and valises	1880	378	3,961,256	6,998	2,737,726	11,068,749
Boots and shoes, custom work and repairing	1880	16,013	11,364,273	22,667	7,993,706	30,870,127
Boot and shoe cut stock	1880	172	1,210,300	2,885	735,482	7,531,635
Belting and hose, leather	1880	97	2,749,299	1,229	607,287	6,531,249
Boot and shoe uppers	1880	81	209,264	457	170,425	790,842
Leather, dressed skins	1880	202	6,266,237	5,395	2,441,372	15,399,311
Total	1870	38,990	128,812,105	199,826	76,150,297	385,241,254
Leather, tanned, curried, and finished	1870	7,459	59,784,362	54,345	14,108,201	154,377,625
Saddlery and harness	1870	7,607	13,935,961	23,557	7,046,207	32,709,981
Leather goods, pocket-books, trunks, and valises	1870	295	2,638,389	4,329	2,171,416	9,091,543
Boots and shoes	1870	23,428	48,934,366	135,889	51,972,712	181,644,090
Belting and hose, leather	1870	91	2,118,577	808	454,187	4,558,043
Leather, dressed skins	1870	110	1,340,450	898	397,574	2,859,972
Total	1860	21,556	70,718,431	165,068	44,308,830	187,552,528
Leather, tanned, curried, and finished	1860	5,175	38,908,170	26,145	8,144,278	75,318,475
Saddlery and harness	1860	3,621	6,478,184	12,285	4,150,365	14,169,037
Leather goods, pocket-books, trunks, and valises	1860	214	1,244,000	3 160	901,741	4,163,956
Boots and shoes	1860	12,486	23,357,627	123,026	30,938,080	91,889,298
Boot and shoe cut stock	1860	1	25,000	15	8,184	149,740
Belting and hose, leather	1860	46	588,000	354	134,952	1,481,750
Leather, dressed skins	1860	13	117,450	101	31,230	380,272
Total	1850	21,679	40,232,503	145,988	31,877,342	109,734,643
Leather, tanned, curried, and finished	1850	6,664	22,582,795	25,379	6,492,130	42,932,528
Saddlery and harness	1850	3,515	3,969,379	12,958	3,154,008	9,935,474
Leather goods, pocket-books, trunks, and valises	1850	165	522,610	2,142	543,840	2,213,363
Boots and shoes	1850	11,305	12,924,919	105,254	21,622,608	53,967,408
Belting and hose, leather	1850	8	40,800	39	15,208	160,500
Leather, dressed skins	1850	22	192,000	216	49,548	525,370

The United States exports on an average a little over $17,000,000 a year of leather and leather goods, and imports about $25,000,000 worth of goat-skins.

The history of the tanning industry during the last one hundred years is a continuous record of improved machinery and processes. The first leather-splitting machine came in 1808, the leather-rolling machine followed in 1812, and in the same year came the machine so ungrammatically named the unhairing-machine — it should be called a dehairing-machine. The first machine for boarding and graining leather was patented in 1835, and a machine for depilating hides and skins was patented in 1836, this operation being different from that termed "unhairing." 1838 was a banner year for first patents in tanning processes, there being taken out first patents for compounds for bating hides and skins (that is, softening them in a manure mixture); also for processes and machines for whitening, buffing and shaving leather, and of new processes for tawing and currying. Tawing, it should be remembered, is a process

Scrubbing-Machine.
(For cleansing heavy leather after tannage.)

of producing leather by some treatment other than soaking in tannic acid, as by using a solution of alum and salt or by treating with oil, the product in the latter case being usually termed oil-leather.

The first machines for stoning, polishing, finishing, glazing, flinting, creasing, and dicing leather were produced in 1845, coming into use a few years later. Japanned and patent leather made its appearance shortly before the Civil War, as did also pebbled leather. The first leather-stretching machine was patented in 1859, and the first machine for shaving leather to a uniform thickness in 1867. The patenting of leather-measuring machines began in 1877, but a wholly satisfactory machine for this purpose was not marketed until 1904, when the Vaughn Machine Company brought out Beal's measuring-machine. This consists of a pair of rolls having contact points one inch apart. When a side of leather is run through be-

tween the rolls an electrical contact is formed for each square inch of leather. An adding device takes note of these, and when the side has passed entirely through the number of square inches is shown on a register.

During the past twenty years the machinery of the tanner has been almost wholly reconstructed, the modern machines for manipulating the hide having reached a high state of development, and many new patented processes and compounds being in use for tanning, tawing, and depilating. A century ago from twelve to fifteen months were required to tan the hides, and naturally the tanners turned their endeavors towards reducing this time. One of the first devices to assist this end was the barkometer, which was simply a

Vaughn Bark-Cutter.

form of hydrometer adapted to testing the strength of tanning liquors. Green hides are limed and dry hides are sweated for the purpose of loosening the hair, sulphide of soda being used as an assistant to the lime. The hides are next beamed to remove the hair and superfluous flesh and work out the lime and dirt. The most common liquors used in tannage are oak, "union," and hemlock. It is still necessary to leave the hides to soak in the tanning-vats for a considerable length of time; the Duric process for agitating the hides seems to have met with little favor in the United States, though it is used to some extent in Europe.

Chrome-tannage has been increasing in use during the past ten or fifteen years, being now frequently employed for cow-hides and calf-skins, as well as for sheep- and goat-skins. It has come to be very popular for upper leather. The "one-bath" method involves

the use of a neutral solution of chromic oxide. While chrome-tanned leathers do not possess the coloring properties of bark-tanned, they have a great advantage in the matter of time saved, the actual conversion of the skin into leather requiring but a few hours.

Patent or enamelled leather has been increasing in popularity during the past few years. In manufacturing this the skins are dried for several days in a hot room, and after smoothing the surface and moistening it, ground pumice is spread on and rubbed in, the process being repeated a number of times. A turpentine blackening is next applied, and the skin is again dried, this time for several weeks. The leather is then tacked on a frame and varnished with a brush, after which it is slowly baked for about three days. United States manufactures have taken the lead in making patent leather, as indeed they have in the whole boot and shoe industry.

Vegetable tanned leather has to be stuffed with grease to keep it soft, the "stuffing" compound usually consisting of tallow, stearin, and wool-grease. A revolving-drum machine, having pins on the interior of the drum, carries the skin towards the top of the drum, and then drops them back into the compound, which facilitates the stuffing process.

A black surface is produced over the grain of the leather by an application of logwood water, followed by copperas water before the logwood has dried. Glazing- and rolling-machines are commonly employed in addition to blackening-machines.

The sandal was the first attempt at a foot covering in the Eastern world, as was the moccasin in the Western world. One is suited to a hot clime, the other to a cold. The leathern shoe is a combination of the good features of each, and, like everything else we wear, is a development. The shoes made in 1800 were the product of hand-labor. The shoemaker took a side of leather, cut out pieces of the thickest for the soles, used the thinner parts for the sides, and sewed and nailed them all together on a last. The making of one shoe was a day's work. Now the parts of the shoe go through the hands of from 100 to 300 operatives in the making, and in its manufacture not less than fifty, and from that to 100 machines are employed. The United States Commissioner of Labor computed in 1898 that on an average for 100 pairs a man's medium-grade calf shoe passed through the hands of 371 operatives, a woman's cheap button-shoe through 269, a man's fine shoe through 146, and a woman's fine shoe through 140.

Under the old-time process of making shoes by hand there was expended for the labor on 100 pairs of men's medium grade calf

shoes $408. In these days of machines the cost of labor per hundred pairs is $35. On men's fine shoes there was formerly spent for labor $556, and now $74; on women's cheap shoes $109, now $20, and on women's fine shoes $499, now $54.

The average cost of each pair of shoes, boots, slippers, or the like in the United States is $1.19, and each individual in the country wears out two and four-fifths pairs every year. The employment of convict labor has had considerable influence upon the boot and shoe industry. About 1850 it was common to employ convicts in the manufacture of their own shoes and also for shoes to be sold in the general market, and by 1886 there were nearly 8000 convicts employed in making shoes, the value of their product in that year

Vaughn Pendulum Whitening-Machine.

being $11,000,000. Since that time there have been strong efforts to prevent this sort of competition, and the manufacture in penal institutions has been checked, though it still exercises a depressing influence in the trade.

Boston is the centre of the shoe-machinery business. All the important American patents on shoe machinery are controlled in Boston, and the machines are made in New England. The whole country must buy its shoe machinery in Boston, or pay royalties there. Foreigners wishing to adopt American machines buy them from branches of the Boston concern which controls them, and New England experts are sent abroad to instruct buyers in the use of the machines. Thus the shoemaking world beyond the water is

obliged to come to New England for its best machinery, and to go to school to New Englanders to learn to operate it. All shoemaking centres in this country also learn how to run and care for shoe machinery from New England experts, as the Boston shoe machinery people keep a corps of skilled men in every shoe centre to introduce machines, set them up, give instructions in running them, and keep them in order.

The exportation of boots and shoes began in Boston more than one hundred years ago, and by 1865 the trade amounted to more than $2,000,000 yearly. It then fell off until 1895 when manufacturers made an effort to re-establish foreign sales, securing exports that year of a little over $1,000,000, which have since grown to about $6,000,000.

Following are the figures for 1902: Total exports, $6,182,088; to the United Kingdom, $2,013,890; Australasia, $955,230; Canada, $523,624. The exports of boots and shoes to the United Kingdom during six years were: in 1897, $300,978; 1898, $352,755; 1899, $525,242; 1900, $950,267; 1901, $1,552,623, and 1902, $2,013,890.

Twelve years ago Great Britain took only $2169 worth of boots and shoes from the United States.

The following report from United States Consul McCunn at Dunfermline, Scotland, shows how the English manufacturers are preparing to repel the invasion of American shoes:

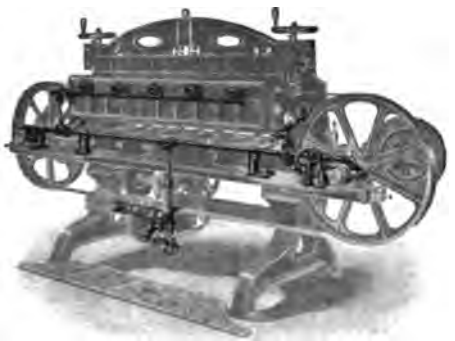
"Nearly all the boot shops handle American boots and shoes to a greater or less extent, and other articles of American import carried by dealers generally throughout Scotland are usually to be had in the shops here. While American boots and shoes are as popular as ever, and continue to hold the prominent place gained in the British market, it is likely to be but a question of time when the imports of boots and shoes from the United States must necessarily fall off, as British manufacturers are now turning out a class of boots and shoes in style, finish, and quality like American made boots and shoes. Retail boot shops, even in the smaller towns, are advertising boots made to order on American lasts. The new machinery and American lasts, which the British manufacturers were once so slow to adopt, are now enabling them to turn out an easy fitting, ready-made boot, in a variety of sizes, that in every way satisfies the wants of the trade."

Shoe-pegs were invented in 1811 by a Yankee, and began to come into general use within three or four years. Up to this time shoemakers had worked mostly each in a little shop by himself or with one or two companions, one making a whole shoe from beginning to end. Where a few worked together, it often became apparent that one man could do a portion of the work better or quicker than the others, and they began to divide the work according to their

special abilities or tastes. Soon there were some energetic men who prospered by hiring perhaps ten or fifteen workmen and dividing the work systematically.

Thus was the shoe factory originated, and when the era of machinery began about 1850, the workmen were ready to take advantage of it. The rolling-machine came first, and the splitter- and racing-machine (for cutting the leather from the side into strips) both appeared before 1860. A hand-pegger was patented in 1833, and was used by a few; the Gallahue pegging-machine, which required to be operated by power, was considerably in use by 1858, about which time it became customary to supply shoe-shops with steam-power, in place of the horse-power and man-power previously employed.

In 1860 came the McKay sewing-machine, which created a tremendous revolution in methods of shoe manufacture. Before its



Belt-Knife Splitting-Machine.
(With Chilson auto-attachment for regulating the knife-grinder.)

time soles were sewed on by hand-labor in most laborious fashion, each requiring a good hour's work; the McKay machine sewed soles at the rate of 500 to 600 a day, and by 1874 there were 1200 of them in use in the United States, and in 1895, 4000, with a producing capacity of 120,000,000 pairs annually.

Lasting is the operation of fitting and attaching the upper to the lower parts of a shoe over the wooden last or mould that determines the size and shape. This work was at first done by hand, but after about 1875 was performed by what was known as the "bed" type of lasting-machine, in which the upper was drawn over the edge of the last by pincers or sometimes by friction, and then tacked on by hand. During the last few years of the nineteenth century the automatic lasting-machine was introduced, which employed pin-

cers that automatically drew the leather round the last, while a tack-driving mechanism fixed it in place. A more recent machine is known as the "pulling-over" machine; this has adjustments by which the operator quickly centres the shoe-upper on the last, after which he presses a foot-lever, when the upper is drawn taut and tacked automatically. These most ingenious machines are almost entirely supplanting hand-labor for the lasting of all sorts of shoes.

The universal double-clinch machine for fastening the soles of shoes with clinched bits of wire, instead of sewing them, is a new machine that is being largely adopted.

The Bigelow heeling-machine, for pressing the heel leather into a solid mass, and setting the nails for driving, was introduced about 1870; also the Bigelow attacher, for driving nails and attaching heels. McKay met this competition by bringing out a heeling-machine the same year, and these two machines took the market, and do nearly all the heeling to-day.

The standard screw-wire machine for connecting the sole and upper, by turning a screw and automatically cutting off the right length, came into use about 1875, while the Buzzell edge-trimming machine appeared in the following year. The Goodyear welt-machine, which produces shoes similar to hand-sewed, has been the most conspicuous invention since the McKay machine appeared. In 1880 250 were in use, and in 1885 the number had swelled to 2500, these having a capacity of about 25,000,000 pairs annually. Campbell's welt-sewing machine appeared in 1890, and the Eppler welter and stitcher came into use during the next few years following.

The Davey pegging-machine has revolutionized the manufacture of pegged boots and shoes. The work is pegged on a horn, thus saving the lasts, which were cut rapidly under the punctures of the pegs. There are cutting devices in the tip of the horn that shear off the projecting ends of the pegs as fast as they are driven.

In the census year 1900 there were 16,000 shoe factories in the United States, with a total capital of $102,000,000, and giving employment to 150,000 persons, of whom one-third were women and children. The cost of the leather and other materials used was $170,000,000 a year, and the product sold was valued at over $261,000,000. The business has only shown normal growth during the past twenty years, having increased some thirty-three per cent., or about as fast as the population of the country. The number of wage-earners is actually less for the amount of product than it was either ten or twenty years ago, improved machinery enabling the manu-

facturer to produce more shoes with less labor. Twenty years ago shoes used to pay a profit to both manufacturer, jobber and dealer, and the wages of the salesman of each had to be added to the price that the public paid. This condition has been largely altered, and the manufacturers and retail stores now have very close relations, so that the public buys its shoes at but a slight advance on manufacturer's costs.

Another change in business methods has been the growth and development of the contract shops, which undertake a specific portion of the work of making a shoe and sell it in that condition to the manufacturer who completes the work. These contract shops do such work as stitching, working button-holes, heeling, etc., and are a special feature of the trade in Massachusetts. That State, with its numerous factories at Brockton, Lynn, and Haverhill, leads in the boot and shoe industry of the United States, New York and Pennsylvania following. The following table of materials and products used by the shoe factories of the United States during the year 1900 affords some idea of the large consumption of leather involved:

	Number of Establishments.	Unit of Measure.	Quantity.	Cost of Materials Used.
Materials:				
Sole leather	946	Pounds.	178,504,837	39,192,300
Split leather	273	Pounds.	15,817,460	3,109,729
Calf and kip skins	420	Pounds.	10,569,581	7,069,408
Grain and other side leather	587	Square feet.	131,542,365	15,950,818
Goat-skins	1019	Square feet.	233,050,841	35,398,638
All other upper material	881	Square feet.	98,866,823	15,578,659
Sheep and leather linings and trimmings	1322	.....	.....	7,429,156
Cut soles, taps, heels, etc., purchased	986	.....	.....	17,248,898
Findings, purchased	1553	.....	.....	12,902,750
Fuel, rent of power and heat, mill supplies, freight, and all other materials	.....	.....	.....	15,723,698
Total	6987	.....	668,351,907	$169,604,054

RUBBER AND RUBBER GOODS

INDIA rubber, or caoutchouc, as it is technically called, is made from the gum of the rubber tree, which grows principally in South America, Central America, Mexico and the East Indies. What is known as Para rubber is regarded as the best, being named from a province in Brazil whence it is obtained. The Para rubber-tree (*Hevea Guianensis*) grows to a considerable size, being sometimes a hundred feet in height, with a handsome spreading top and glossy

Tapping a Rubber-Tree.

Curing Rubber.

foliage. The method of securing the rubber is to tap the trunk near the base, drawing off the sap into a cup, much as a maple-sugar tree is tapped. Used in its pure state, rubber is almost valueless, because it melts with a slight degree of heat; it therefore requires to be mixed with something that will check this tendency. The original Goodyear method for rendering rubber useful and destroying its adhesive properties consisted in applying an acid solution of nitric acid with copper or bismuth; lime was also incorporated with the gum for bleaching it. The vulcanization of rubber came a little later, the original process being the dissolving of sulphur in oil of turpentine, and mixing this with the gum before subjecting to the treatment with a metallic acid solution; after which the composition was subjected to a temperature of about 275° to 300° F. for six or eight hours. What is known as soft rubber contains only

a small portion of sulphur, while the hard rubber, sometimes called ebonite or vulcanite, contains twenty-five to thirty-five per cent. of sulphur and requires to be heated for a longer period.

When Charles Goodyear began studying and experimenting with India rubber, he was confined in a debtor's jail, having failed in the hardware business in Boston. He studied the problem to such good advantage that within ten years he was the leading figure in the rubber industry, and the house which he founded became dominant in the rubber trade.

The Civil War gave an impetus to the rubber industry by creating a demand for rubber blankets for the soldiers. A little later

View in Rubber Works, showing Calendering Machine.

the railways became large customers, using it for packing and for hose-pipe. It also came into considerable use for belts, vehicle tires, floor tiles, and parts of various machines and tools. There is a large demand in the manufacture of rubber stamps and rubber balls, and of cushions for billiard-tables, and rings for fruit jars. The mackintosh began to replace the old waterproof coat about 1883, and some twenty factories now manufacture them. The making of rubber articles for druggists' sundries is also a considerable business.

In 1892 the United States Rubber Company purchased nearly all the rubber footwear concerns, securing a considerable reduction in operating expenses, especially in the price of crude rubber. This company does most of the business of the United States and also sells to a very large part of the European trade. They kindly furnished the illustrations for this article.

When the crude rubber is drawn from the tree it is first subjected to a process of fumigation over a fire of brushwood or palm-nuts. In this manner it is considerably condensed, so as to be fit for shipment. When this crude rubber reaches the manufacturer it is liable to contain more or less bark, dirt, and foreign substances, and in order to get rid of these it is softened in hot water for a number of hours, after which the lump is sliced and the larger impurities removed by hand. It is then passed through corrugated rolls, being at the same time subjected to a washing; this rolling and washing are repeated until the rubber is wholly purified. Sulphur and lampblack are then worked into it for the purpose of hardening and coloring.

Rubber Boot Manufacture.

Rubber boots and shoes, rubber blankets, and a great variety of other articles commonly spoken of as being made of rubber, include a basis or fabric of stout cloth, which give strength as well as form to the rubber. In making these, the sheet of rubber is passed through the calendering-machine together with a stout backing of cloth, till the two are incorporated into one fabric. Such fabrics are made in different thicknesses for making the different parts of a shoe or boot, the top, soles, heels, etc., being cut out with dies. These parts are brought together on forms or lasts, and cemented with rubber, after which a coat of rubber varnish is applied, and the completed shoe is taken to the vulcanizing oven.

The Roxbury India Rubber Company, which began business

in 1833, is said to have been the pioneer concern in the United States, their work being based on the discoveries of a Mr. Chaffee. Charles

Grinding and Cleaning Rubber.

Goodyear came into the industry a little later, and made important improvements. Alexander Parks, of Birmingham, discovered the

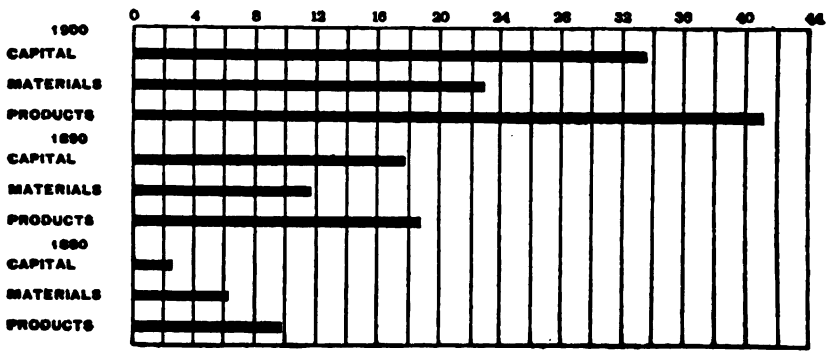
Varnishing Rubbers.

process known as cold vulcanizing, which is accomplished with chloride of sulphur.

Good soft India rubber, as manufactured to-day, will retain its

elasticity at a heat as great as 248° F. and cold as low as —22° F. It cannot be dissolved by ordinary solvents.

The growth of the boot and shoe rubber industry in the United States by decades is well shown in the following table, taken from the United States census report. From this it is apparent that the business is doubled about every ten years. Although there were only twenty-two rubber manufacturing concerns in the country in 1900, their total capital was nearly $34,000,000. The industry is principally confined to Massachusetts, Connecticut and Rhode Island, although there are two factories in Pennsylvania, two in New Jersey, and one in Missouri. Most of these concerns manufacture other rubber goods besides boots and shoes, but the footwear constitutes by far the largest part of their output. The aggregate value of the rubber boots and shoes manufactured in the United States in the year 1900 was over $41,000,000, this representing 50,000,000 pairs of boots, shoes, tennis shoes, and what are technically known as felt boots. The six establishments in Massachusetts control nearly one-third of the business of the country. The industry gives employment to 18,000 people during the busy season, of whom about three-eighths are women. There are no complete statistics of the products of other rubber goods.



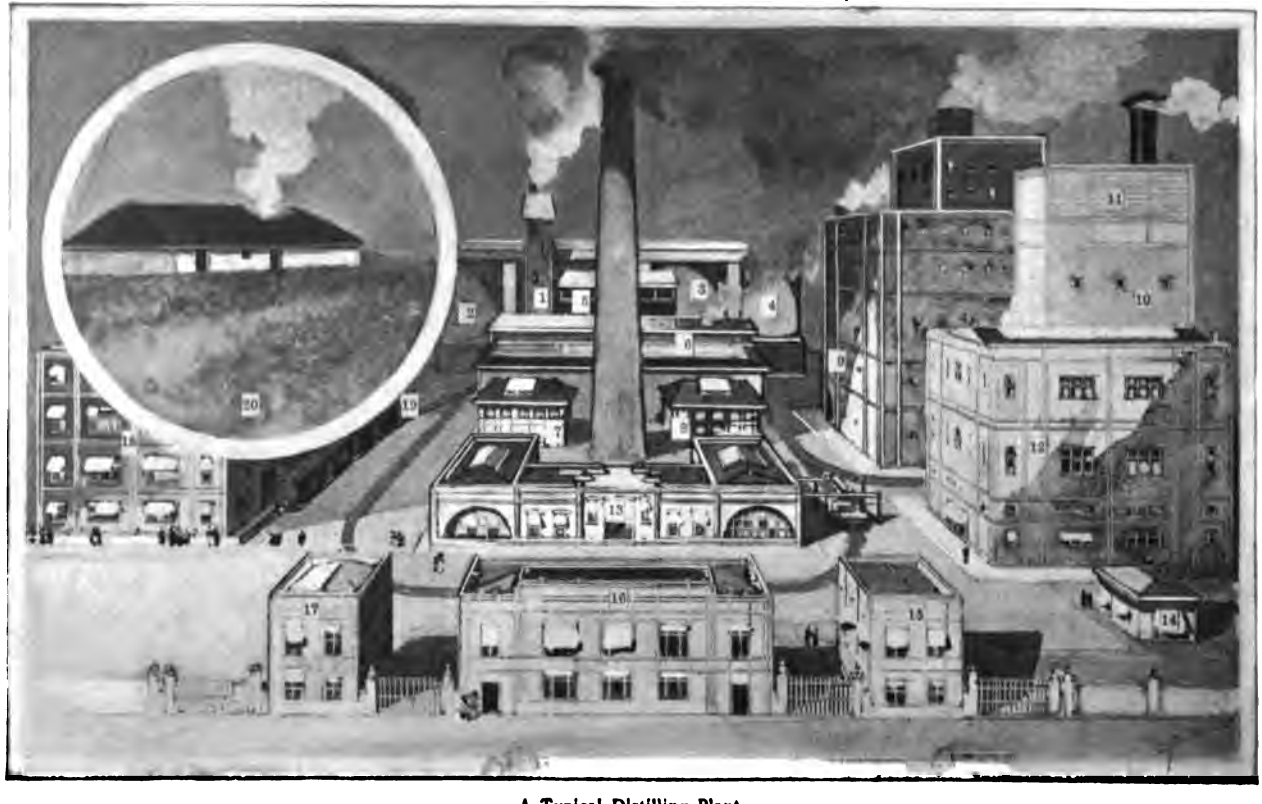
Rubber Boots and Shoes.
Comparative increase of capital, material, and products, 1880 to 1900 inclusive.
Millions of Dollars.

THE MANUFACTURE OF LIQUORS

THERE are three distinct branches of liquor manufacture—distilling, brewing, and wine-making. The strong liquors, such as alcohol, whiskey, gin and rum, are made in distilleries; malt liquors, as beer, ale, and porter, are made in breweries; while the manufacture of wine is carried on mostly in small establishments by the old-time process of simple fermentation and aging. The principle upon which distilling is based is that alcohol boils or vaporizes at 173° F., while water requires a temperature of 212° F. before it begins to boil and make steam. Any aqueous liquor containing alcohol, when heated over 173° and under 212° F. will give off alcoholic vapor, which has only to be condensed again to secure alcohol. The process is therefore so simple that it may be accomplished without expensive machinery.

The production of alcohol by natural means is brought about by a ferment, which adds a small percentage of alcohol to the liquor affected. The origin of alcoholic drinks is lost in antiquity. Beverages made from fermented fruits were known to man at the earliest period of human history, but distilled liquors, which are stronger in alcohol, are comparatively modern, coming into being with the invention of the still. The early fermented liquors were made of fruits or brewed from hops. Now corn, wheat and rye are the principal sources of alcoholic or distilled liquors. Since distilled or spirituous liquors came into general use there has existed a strong movement in favor of restriction of the traffic and sale, which has found expression in temperance agitation, and sometimes in prohibition; and has frequently resulted in legislation to tax and regulate the traffic.

The strong liquors are mostly distilled from grain, because grain is cheaper than fruit; corn, wheat and rye are the grains principally favored by the distiller. In Pennsylvania, Maryland, and West Virginia mostly rye whiskey is produced, while most of the Tennessee whiskey is made from wheat, and corn whiskey is made in nearly every State in the Union. The United States census of 1900 reports 2835 establishments engaged in manufacturing liquors, of whom 967 are classed as distillers, having a total capital of $33,000,000. As a matter of fact, about a dozen concerns have nearly all the capital and do nearly all the legitimate distilling



A Typical Distilling Plant.

1, Grain elevator; 2, 3, and 4, granaries; 5, coal-chutes; 6, boiler-house; 7, auto-truck house; 8, machine-shop; 9, malt-house; 10, mash-house; 11, cooler; 12, still-house; 13, power-house; 14, revenue house; 15, laboratory; 16, business office; 17, mail order department; 18, packaging department; 19, warehouse; 20, ancient Irish distillery making potteen whiskey.

that is done in the country. The malt-liquor trade is very much larger, not in the number of establishments, there being but 1509 breweries in the country, but in the capital invested, which is $415,000,000, and in the number of people employed, which foots up 47,000, or more than ten times as many as the distilled-liquor and wine-making trade combined. The distillers use up $15,000,000 worth of material annually to produce $97,000,000 worth of distilled liquor, while the breweries use up $52,000,000 worth of material to produce $237,000,000 worth of malt liquors. It would appear from the value of this product that the distilling industry was over forty per cent. as large as the brewing industry, but this is not the case; the value of the distilled liquor being very largely created by the Government tax, which since 1865 has varied all the way from fifty cents to two dollars per gallon of proof spirits—that is to say, from two to six times the value of the liquor itself.

In 1900 24,000,000 bushels of grain were used for manufacturing alcoholic liquors in the United States, producing an average of 4.16 gallons per bushel. Of the different grains used sixty-eight per cent. was corn. These figures, of course, only include such liquor as was manufactured in a legal and public way, and subject to taxation. The amount of alcoholic liquor made in illicit distilleries is known to be large, because of the great temptation offered by the difference in price, but the quantity so made cannot even be estimated. It is certain that the people of the United States consume an average of one and one-fifth gallons of legitimate strong liquors every year. The proprietors of large distilleries often complain bitterly of the way in which the business is taxed, but public sentiment appears to favor this method of securing a large public revenue.

The distilleries make the largest quantity of spirits during the winter months, there being five times as much manufactured in January as in August. The production of any one month or one year is no indication of the consumption, as a great part of the product manufactured is placed in bonded warehouses, where it is subject to the watch and care of Government officials, but is not required to pay a tax within eight years, unless it is taken out. Under these conditions it has become important for the manufacturer and the Government also to know exactly the percentage of alcohol in given liquors, and the measurement of this has become a very exact science. The rectified spirit, or so-called pure alcohol of the druggist, has nine per cent. weight of water; while what is known as proof spirit is 54½ per cent. water, according to United States statute.

Views in a Brewery.
1, The fermenting vats; 2, the brew-kettle room; 3, portable filters.

While beer was brewed in New York by the early Dutch settlers, lager beer was not brewed as a business until 1843, when a brewery was established in New York at Broadway and Nineteenth Street. About the same time a brewery was started in Philadelphia. Curious as it now seems, lager beer became the fashionable drink, and was bought by the bucketful by the swell families of New York for their Sunday dinners and other important occasions, whiskeys (which were not then taxed) being too cheap to be regarded as good. Thus it happened that William F. Havemeyer and Daniel F. Tiemann (each of them afterwards mayor of New York) were among the first customers of the brewery.

Lager beer was principally a winter drink until the introduction of ice enabled the brewing of a summer supply. The American still demands a colder beer than the German requires. It was not until the industry had been established many years that it became customary to put up the beer in barrels and kegs.

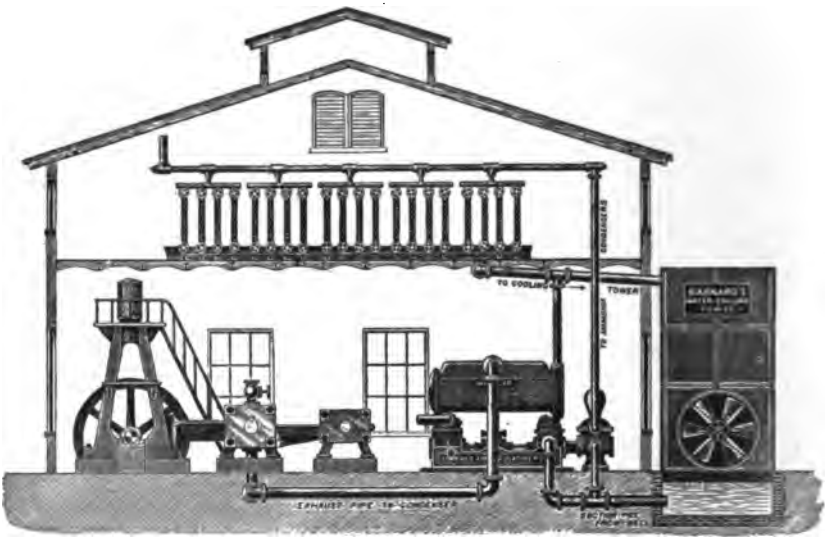
The breweries of the United States did not have such an enormous lead in business over the distillers before the Civil War; but the heavy taxes imposed on the distillers at the time of the war created a condition favorable to the brewers, of which they took full advantage, as appears by the following figures: in 1863 the production of beer in the United States was 2,000,000 barrels; by 1870 it had risen to 6,500,000; by 1880 to 13,350,000; and by 1890 to 27,500,000, and by 1900 to 39,330,000 barrels.

During the ten years from 1890 to 1900 the materials used by the brewers decreased in cost over nineteen per cent., while the value of the product sold increased almost thirty per cent.; nearly all of this increased value, however, being attributable to taxation. The reduction of cost in manufacture came from the lower prices at which hops, barley, and corn were purchased, and to improved methods of manufacture, causing a more thorough extraction of the malt liquor.

The growth of the brewing industry of the country is more noteworthy when a comparison is made between its condition in 1850 and 1900. During that period the number of establishments making malt liquors increased from 431 to 1509; the invested capital increased from $4,000,000 to $415,000,000; the value of the products increased from $8,000,000 to $237,000,000. The taxes paid the United States Government in 1900 by the brewing industry amounted to $104,000,000, or about one-tenth of the entire expenses of the Government.

A prominent cause of the increased capitalization of breweries

during recent years has been the investment required in new machinery required to make better and cheaper beer. It is asserted that American-made beer is now both the best and the cheapest in the world. As formerly manufactured, beer was subject to all sorts of diseases arising from bacteria, but the investigations of Pasteur, Hansem, and others were taken advantage of by the brewers to introduce more scientific methods of manufacture. They now use closed apparatus for cooling, and employ for ventilation air that has



Barnard's Water-Cooling Apparatus for Breweries, etc.

been filtered and rendered germ-proof; the water is also sterilized, and the whole product protected from the time it leaves the hop-brew kettle until the stopper is removed from the bottle by the consumer. The introduction of the ice-machine has been a very great advantage to brewers, who rely on it in a great many of their modern processes. Another improvement is the collection and utilization in its purity of the carbonic acid gas formed during fermentation. The finished product is now charged with the best natural carbonic acid gas to give it the necessary life and sparkling quality.

In 1894 the leading brewers of the country formed an industrial combination for protecting the industry, this being generally known as the Brewers' Trust.

France is the wine-making country of the world, Italy being second, and Spain third, while the United States is practically no-

where, as shown by the following table of the world's crop of wine for 1901:

France	1,530,000,000	gallons.
Italy	1,013,000,000	"
Spain	520,000,000	"
Portugal	155,000,000	"
Algeria	146,000,000	"
Austria	116,000,000	"
United States	40,000,000	"

The above shows how insignificant is the wine-making industry of the United States. Nearly all the wine we make is produced by small concerns in the districts where the fruit is grown, though there are a few large establishments.

The bottling industry of the United States comprises a total of sixty-four establishments, capitalized at $17,000,000; employing 8000 wage-earners, and selling products valued at $42,000,000. The mineral-soda and soda-water manufacturers number 2815, have a capital of $21,000,000, employ 9000 workers, and make annual sales of $24,000,000.

Of course, conditions of the liquor industry are affected largely by the state of public sentiment. Those who regard fermented and distilled liquor as an evil, think that the larger the business the worse off is the country; while those who look upon the production of liquor in the same manner they would regard the manufacture of stoves, view the large proportions of the industry in America as one indication of national progress and development.

THE TOBACCO INDUSTRY

THEORETICALLY, tobacco is a luxury; practically, it is a necessity with four men out of five. No acquired habit has a stronger hold on human kind than the use of tobacco. Twenty-five years ago only about half the male population over fifteen years of age were addicted to smoking; now it is hard to find one man in twenty who will refuse a cigar. The tobacco plant is one of the most highly cultivated, yielding the farmer a larger return per acre than almost any other crop; $400 worth of tobacco is not an uncommon yield per acre under good management. The leaves of the plant are prepared for use by a process of curing which consists in exposure to air and moisture under certain conditions, the result being a fermentation that develops the aroma and flavor. The nature of the tobacco is graded as trash, lugs, seconds and leaf. The leaf is still curing as by the growing of the plant.

Inasmuch as most tobacco is made into cigars, the leaves are primarily graded for use as fillers, binders, and wrappers; chewing-tobacco is graded as trash, lugs, seconds, and leaf. The leaf is still further sorted as short, long, dark, red, bright, mottled and yellow, as to color; and as to moisture, into light, heavy, gummy and fatty. For export there are also grades known as spinners, saucers, cutters, shag, regie, bailers, etc.

The ordinary tobacco plant is technically known as *Nicotiana Tabacum,* and grows from three to six feet tall, having large oval pointed leaves and pink funnel flowers. Kentucky and North Carolina are the leading tobacco-growing States of the South, while Connecticut takes the lead in the North.

Each tobacco plant is supposed to yield suitable material for use as fillers, binders and wrappers, but, as a matter of fact, the soil that grows the best wrappers does not give the best fillers, and therefore the best cigars are apt to be made from tobacco grown in different sections. In the Connecticut Valley the farmers grow a fine wrapper and binder, while in the strong heavy soil of Ohio there is grown a dark tobacco that is more suitable for fillers, or for export to a market that prefers a dark tobacco. Along the rivers of Pennsylvania there is good soil for growing wrappers, but away from the rivers the crop is principally suited for fillers.

The methods of growing and curing tobacco vary more or less

with the locality. In Connecticut the custom is to plant the tobacco in rows three and a half to four feet apart, the plants in each row being eighteen to twenty-four inches apart. The small black seeds are first sown in mellow beds of rich ground that are sheltered, the seed being sprouted between sods or in decaying wood. The growth of the small plant is expedited by placing under glass. The sowing is done about the beginning of April, if the frost is all out of the ground, and the plants are ready for transplanting two months later. The soil having been previously well plowed and harrowed, fertilizer is put into the hole with each plant, which is also well

Courtesy Frank Leslie's Popular Monthly.

Duke's Original Factory at Durham, North Carolina.

watered. While the plants are growing, the cultivator is run through three or four times to kill off the weeds. The plant is topped by taking off the surplus leaves until only fifteen to eighteen remain, the number being determined by the thriftiness of the plant. In about ninety days, when the middle leaves of the plant are ripe, comes the time for cutting. Each plant is cut close to the ground with a hatchet or saw, and laid in the sun to wilt. Care must be taken not to do this when there is danger of a rainstorm. After perhaps two hours of exposure the plants are strung five or six on a lath, and carried to the barn, where they are hung on poles. The best tobacco barns are provided with artificial heat, and after the

plants have dried on the pole for eight or ten weeks, the leaves are stripped from the stalks, this work being done on damp days in order to avoid breaking the leaves through brittleness; if there is no damp weather the butts are sometimes sprinkled. After stripping off, the leaves are put in paper-lined boxes, and in these boxes they are usually sold to dealers, bringing a better price if first sorted and tied into bundles.

Fermentation or sweating is usually done by the packers. For this purpose large wooden cases, holding about three hundred pounds each, are used; the boards of the cases are placed about half an inch apart to allow a circulation of air. On the bottom of each box is placed a layer of seconds, as the outside does not sweat readily. The leaves are packed with the butts out, and are tightly pressed so as to exclude the air, the top of the box being screwed on. These boxes are stored in a warehouse to sweat, remaining in the cases all winter, so that the tobacco never reaches the consumer until it is at least a year old. If it were not kept and sweated and fermented, it would not have the aroma and flavor that smokers enjoy.

A favorite tobacco is the white Burley, grown in the blue-grass region of Kentucky and Ohio. This plant is white while young, and has a long narrow leaf. It is rehandled and resweated by manufacturers, and when cured has a reddish-brown leaf of mild flavor and great absorbing quality, which latter admits of making a sweet chewing plug. The Sumatra tobacco is "petuned" by spraying or sometimes by dipping into a thick fusion made of tobacco stems of the best quality, to which are added molasses, cider, rum, or sometimes sour wine. It is stored for at least two years after petuning, losing the harshness of fresh tobacco and improving with age.

The light yellow tobacco of the Carolinas is grown in sandy soil and topped down to eight or twelve leaves. The Connecticut and Pennsylvania seed-leaf tobacco is silky when cured, and is characterized by a broad and thin, though strong leaf. The Cuban tobacco has numerous leaves, is small and fragrant. The famous Perique tobacco is grown in the wet bottom lands of Louisiana, and owes its peculiar flavor and aroma to the method of curing in its own juices. It has a fine fibre, medium leaf, and is rich, gummy, and dark, being so strong that it is commonly mixed with milder kinds. In curing it is subjected to pressure, which is relieved once a day (so that it can be aired) during the first ten days, and after that at longer periods. By this treatment the juices are squeezed out and reabsorbed, until they permeate the whole, and the leaves become quite dark. The manner of putting up this tobacco is unique,

it being rolled in cloth and wrapped with a small rope, the packages usually weighing four pounds each, although they are sometimes made smaller.

Tobaccos for export are put up with regard to the taste of the trade in the country to which they go. Indeed, this is largely true of the United States also, as some localities demand a different color or flavor from others. Tobacco for German use requires to be fat, heavy bodied, and with a strong and tough leaf of considerable length, but the fatness is the chief requisite. The Italian trade calls for a lighter tobacco, smooth and silky, with more attention to

Courtesy Frank Leslie's Popular Monthly.

The Present Duke Factory at Durham. (Branch of the Tobacco Trust.)

length than fatness. The French demand a still lighter tobacco, preferring a reddish color, and do not care much for fatness or elasticity, but demand a clear leaf that is supple. The English trade demands tobacco very similar to the German, while Spain takes the poorest quality of tobacco that is exported from the United States.

The manufacturing of tobacco in the United States has become concentrated within recent years, the American Tobacco Company, popularly known as the Tobacco Trust, exercising a dominating influence in the wholesale trade of America, and having close relations with the Continental companies. The one man who more than any other brought about this result is J. B. Duke, president of the

American Tobacco Company, whose first and last factories are here illustrated through the courtesy of Frank Leslie's *Monthly*. The trust idea grew out of the development of the cigarette business, which began to boom in 1876. By 1880 the cigarette trade was thirty times as great as in 1870. The total was again doubled by 1885, and again in 1890, the output of the latter year being over two billion. The Duke concern became very active in the cigarette field, being lavish advertisers. So much money was spent by the five leading firms in trying to outdo each other that Mr. Duke made a successful effort and consolidated them in 1890, when the American Tobacco Company was formed. After that a contest was waged with the Lorillard Company and Leggitt & Meyers, the chief weapon being " Battle-Ax," a brand of plug manufactured by the American Company on which they spent $4,000,000 and made $12,000,000. Then there was a long advertising war between the American's " Honest" and Lorillard's " Red Cross,"—Leggitt & Meyers, and Blackwell's Durham Company, and the National Cigarette and Tobacco Company being parties to the general struggle for business. In 1898 all these concerns consolidated as the Union Tobacco Company, with the apparent object of fighting the American Tobacco Company, but six months later Mr. Duke took them all into the latter company, which at this writing has no real competition in the cigarette trade of America, the smaller dealers contenting themselves with calling their wares anti-trust. The American Cigar Company is an offshoot of the American Tobacco Company, and so is the Havana-American Company and the Havana Tobacco Company. It has also been charged that the United Cigar Stores Company is a creature of the trust, but this is officially denied.

An international tobacco war was started in 1901, when the capitalists of the American Tobacco Company secured Ogden's Limited, a well-known brand of British tobacco, and began pushing for British trade with American advertising methods. After a short struggle with the Imperial Tobacco Company, peace was declared, and they purchased Ogden's Limited at Mr. Duke's figure, while the British Company agreed to keep out of the United States and its dependencies.

An important feature of the development of the cigarette business during the last few years has been the popularity of Turkish cigarettes, which are nearly controlled by the American Tobacco Company, so that the trust now has a dominating position in the cigarette, manufactured tobacco, and snuff trade, while it has a prominent position in cigar manufacturing.

The retail value of the tobacco annually consumed in the United States is figured at $500,000,000, the total number of cigars smoked being 7,000,000,000, while 3,000,000,000 cigarettes and 280,000,000 pounds of manufactured tobacco go to make up the remainder of the total.

The United States imported in the fiscal year ending June 30, 1903, 34,000,000 pounds of tobacco, valued at $17,250,000; we exported over ten times as much—377,000,000 pounds—valued at $40,500,000. The price shows that the imports were a much higher grade of tobacco than the exports. The following figures are from the census of 1900:

Tobacco was grown in the United States in 1899 by 308,317 farmers. The total area devoted to the crop was 1,101,483 acres, and the total production was 868,163,275 pounds, an increase in area since 1889 of 406,182 acres, or 58.4 per cent., and a gain in production of 379,906,629 pounds, or 77.8 per cent. Of the entire area devoted to tobacco, 465,754 acres, or 42.3 per cent., were in the South Atlantic division. Of this amount North Carolina contributed 43.6 per cent. and Virginia 39.6 per cent. The South Central division contained 461,855 acres, or 41.9 per cent. of the entire acreage, and of this amount Kentucky, which leads the country in tobacco production, contributed 83.3 per cent. The North Atlantic division contained 4.8 per cent of the entire acreage, and the North Central 10.9 per cent., with only fifty-four acres reported from the Western division. The total value of the crop in 1899 was $56,993,003, or an average of $184.85 for each farm reporting. The average yield per acre was 788 pounds, and the average value per pound to the producer seven cents.

Of the tobacco manufactured in 1898, 286,453,738 pounds were in the form of chewing and smoking tobacco and snuff, and 106,855,524 pounds in the form of cigars and cigarettes.

PETROLEUM AND OIL REFINING

OIL was first "struck" in the United States in 1858, and for the past quarter of a century it has been one of our leading industries. The search for precious metals and valuable jewel stones has driven men to mining in the far-off regions of the earth, often going deeper and deeper in pursuit of a rich vein. But when oil is struck, it rushes to meet the finder, and his care is to provide for and save the flood of oily riches poured out by the gushing well. In the early days of oil-wells much of the product was often lost because of inability to store the oil in barrels or carry it off as fast as it flowed, and this is still the case in new fields where there are no pipe-lines or the tankage is inadequate.

For many years we led the world in the production of petroleum, but in 1897 Russia passed us in the quantity obtained from her wells, but the United States recovered first place in 1902. We lead the world in the refining branch of the industry. The probabilities are that Russian oil-fields will increase in production, and that they will learn to do more refining, which will injure our export trade. At the present time their facilities for handling oil are comparatively crude, and their markets are at a distance. With more pipe-lines and more modern American pumping machinery and up-to-date refineries they will naturally secure the bulk of the trade of the Old World.

Petroleum was first observed as oil floating on the creeks in Pennsylvania and was gathered by the Indians by spreading blankets on the oily water. Well-digging began in 1858–59, the first wells being literally dug into the ground. Then came the method known as "jerking down a well." This consisted in attaching a falling tool to a spring pole, and alternately raising and dropping it. This method was improved upon by operating what were known as free-falling tools by a horse-power, the horse being led around in a circle. An advanced method was introduced later by operating the tools with a reversible steam-engine, known as a link-engine, such as that here illustrated, made by the Oil Well Supply Company, of Oil City, Pennsylvania. Steel derricks are built sometimes nearly 100 feet in height, from the top of which the falling tools are suspended by a rope, being hauled up by the engine and allowed to drop into the hole, which is thus deepened at every stroke.

Different methods of drilling are sometimes required, owing to the nature of the substrata through which the tools have to pass.

In some shallow districts it has been found advisable to use a rotary drill, though this method is not very common. In other localities, when drilling through loose formations and clay, it is impossible to use free falling tools, and a hydraulic method has been substituted. In the new Texas field clay is often encountered, and for cutting

Courtesy Scientific American.

Oil-Derrick in Java.

through this hydraulic drilling has been adopted to a considerable extent.

At Summerland, California, about a hundred submarine oil-wells are in successful operation, these being located on or off the beach, some of them where the water is twenty-five feet deep at

low tide. The method of drilling these wells differs but slightly from the method followed on land. A large pipe, called a conductor, is run through the water and porous sandy bottom into the hard clay beneath, and through this conductor the casing proper is sunk. A wharf is built from the shore to the derrick, this being usually a substantial pile structure.

When oil is reached, a petroleum well flows for a time from internal pressure, spouting usually with great force. After a time the pressure is relieved, and eventually pumping has to be adopted to bring up the oil. As a well consists of a series of pipes run down to the oil-sand, almost any system of pumping may be adopted, but the use of compressed air for pumping is at this writing coming into favor where the proper conditions exist. The air-pump proper consists of nothing more than two plain pipes, one for air and one for the oil discharged, though sometimes the oil is allowed to gather, and then forced out on the ejector principle.

It is now customary to connect a number of near-by wells so as to pump them in unison. One way of doing this is to secure water-power from some adjacent mountain stream and drive a large wheel, from which the wells are operated by eccentrics and connecting-rods. A method now being experimented with is the establishing of a central power station, furnishing an electric current to drive individual motors at the several wells. This system seems well adapted where a large number of wells can be worked together on a lease. The most common method for general pumping is to connect the wells with surface-rods, which are operated by a gas-engine centrally located. This is a cheap method because the gas used is obtained from the oil-wells themselves, a certain amount of gas almost always being found in some of the stratas through which the wells pass to reach the oil-sand. This gas is prevented from escaping from the top of a well by the casing-head, and gas drawn from this head is known as casing-head gas.

Crude oil is the name applied to petroleum in the condition in which it is taken from the well. No less than two hundred different products are obtained from crude petroleum by what is called distillation and reduction. Distillation is the process of vaporizing and then condensing the vapors into merchantable products; reduction is driving out the lighter parts of the petroleum by heat. It will be recognized that by distillation the lighter portions obtained are in a refined condition, free from any foreign substances that may have contaminated the crude oil. The most important products obtained by distillation are kerosene, benzine, gasolene, naphtha,

lubricating oils for machinery, residuum, and either paraffin or asphalt. The heavier portions are made into petrolatum (or vaseline), and also find their way into candles and a great many other articles.

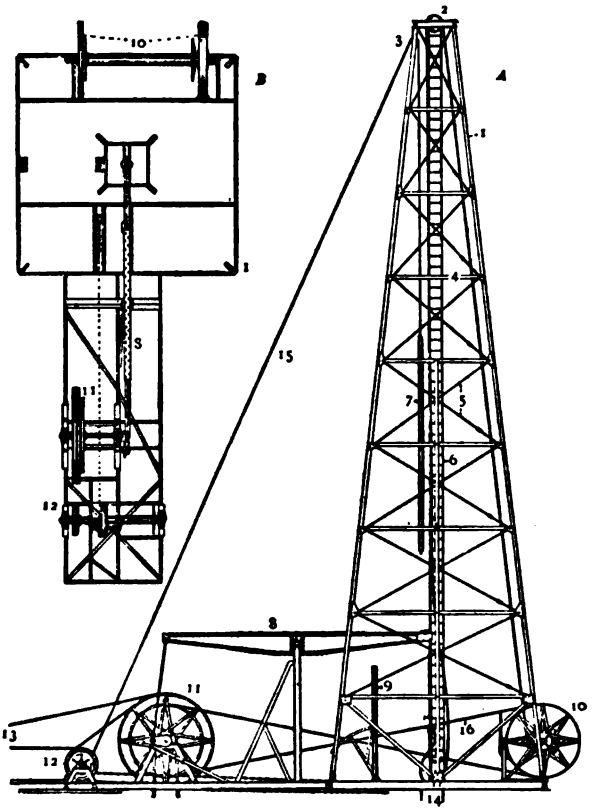


Diagram of a Steel Rig for Drilling Oil-Wells.

A, Upright plan; B, ground plan. 1, Derrick frame; 2, crown pulley; 3, sand-pump pulley; 4, derrick girt; 5, braces; 6, ladder; 7, bailer; 8, walking-beam; 9, headache post; 10, bull-wheels; 11, band-wheels; 12, sand-reel; 13, ropes connecting with steam-engine; 14, top of well; 15, sand-line; 16, bull-rope.

When petroleum was first obtained it was loaded into barrels, and these were shipped on flat-cars. It was found that water mixed with the oil, dissolving the glue used to close the chinks in the barrels, so that they leaked. Wooden tank-cars were then resorted to, these being superseded about 1872 to 1875 by cylindrical iron tank-cars.

The first pipe-line was constructed by Samuel Van Syckle, of Titusville, Pennsylvania, who built a line four miles in length. To-day that oil region is a network of pipes, and great trunk lines

extend between the principal points. In the early days of pipe-lines the well-owners who turned their oil into them simply received a certificate that might or might not be good, but this system was subject to so many abuses and so much loss that the pipe-lines naturally came under the control of a single reliable concern, out of which has grown the Standard Oil monopoly.

The exporting of petroleum from the United States began in 1862, and within a few years developed into a large trade. For many years we have enjoyed the cream of European custom, which is only now being threatened by the development of the Russian oil-fields. In 1901 our exports for the first time exceeded 1,000,000,000 gallons, valued at $74,500,000. More than half of this oil is shipped from New York, and over thirty per cent. from Philadelphia. Nearly every foreign country except Great Britain exacts a tariff from the petroleum we sell to them. More than six-sevenths of the petroleum we export is refined, and of the crude oil we export nearly all is taken by France.

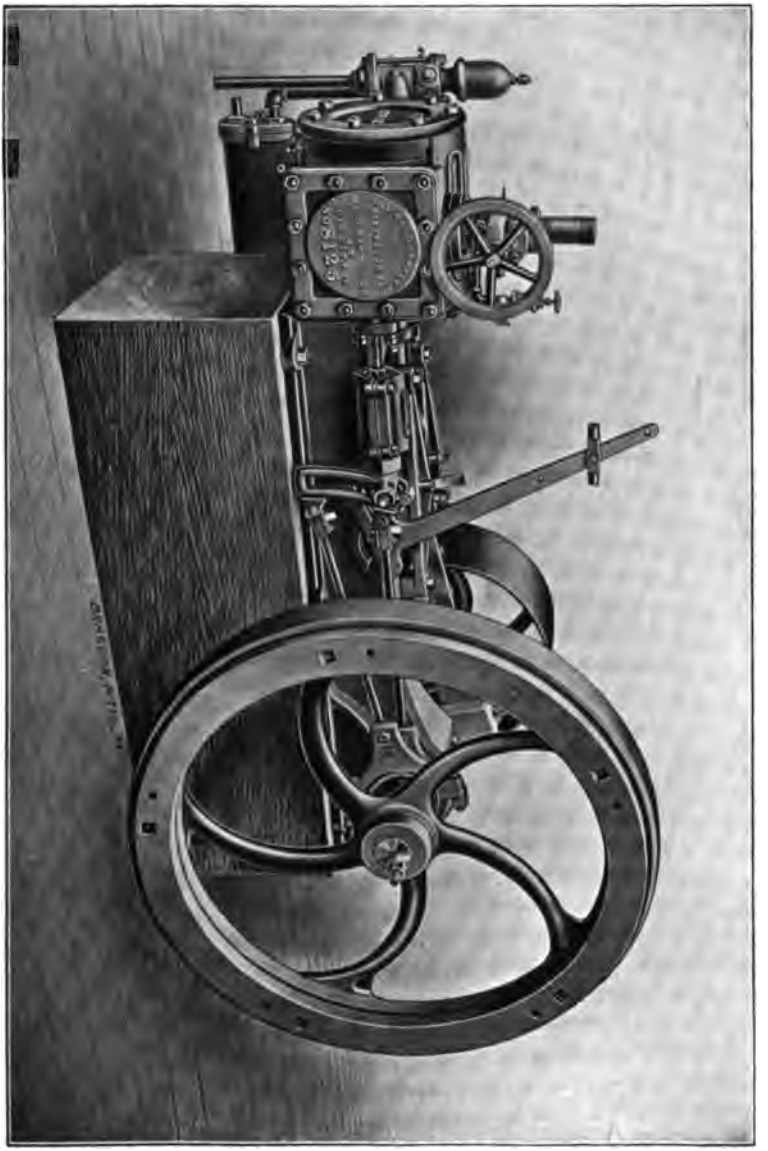
The total production of crude petroleum in the United States averaged about 65,000,000 barrels per year during the years from 1898 to 1902, about one-tenth of this production being exported. Nearly $500,000,000 capital is believed to be invested in the United States in prospecting for oil, pumping and transporting, and refining. There are sixty-seven concerns engaged in the refining business, having a total capital of above $100,000,000. Pennsylvania is the centre of the refining industry, as it is also the principal oil-field of the country, but there are also refineries in the oil-fields in Ohio, West Virginia and Texas, and in a number of other States.

The following table shows the United States census return for 1899 of refined petroleum products and the percentage of increase in ten years:

Products.	1899.			Per cent. of Increase.	
	Number of Barrels.	Total Value.	Average Price per Barrel	On Quantity.	On Value.
Burning oils	31,266,513	$82,244,961	$2.63	84.3	71.9
Residuum	596,615	688,455	1.15	[1]50.1	[1]44.3
Paraffin oils	1,606,783	3,987,037	2.48	134.6	31.9
Paraffin wax	774,924	7,791,149	10.05	220.3	168.2
Reduced oils	1,766,090	7,108,168	4.03	106.1	204.6
Naphtha and gasolene	5,615,554	15,991,742	2.85	70.7	124.7
Neutral filtered oils	608,185	2,256,626	3.71	.....	.....
All other products	.....	3,861,246	.....	.....	[1]81.2

[1] Decrease.

The Appalachian or Pennsylvania petroleum field produced most of the oil obtained in the United States until recent years,

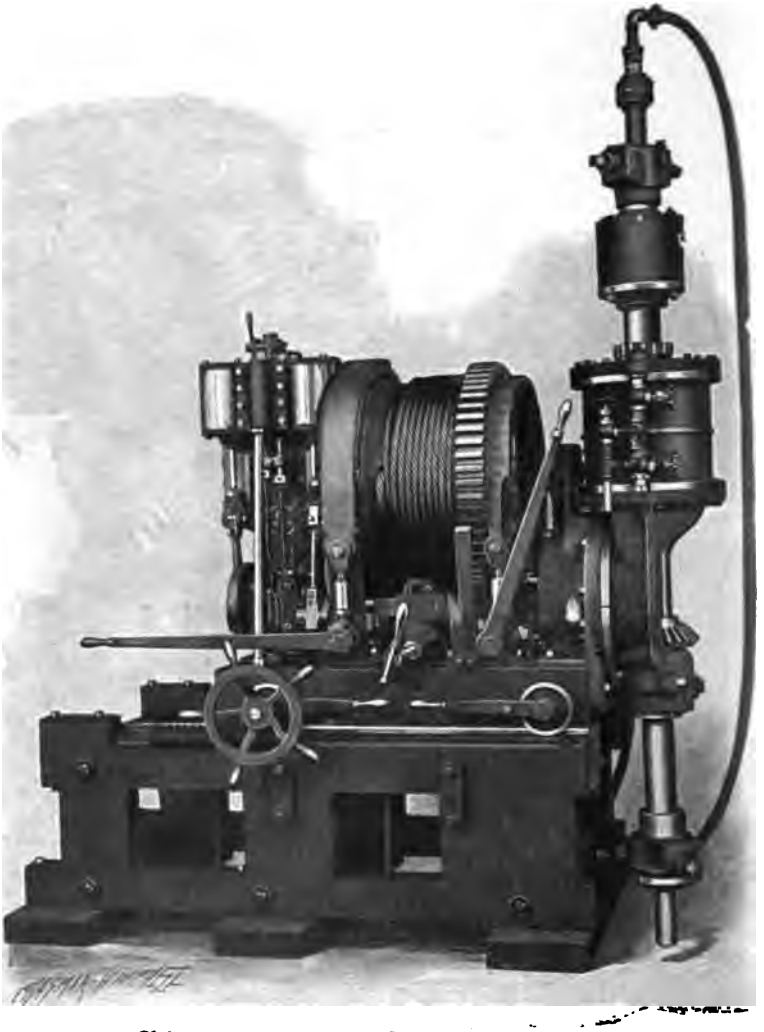


Courtesy Oil-Well Supply Company.

Type of Engine used by Oil Producers.

about 125,000 wells having been sunk there. Since 1895 the Lima-Indiana field has produced nearly three-fourths as much, though since 1900 both these fields have slightly reduced in output. The

new fields of Texas, California, Colorado, Kansas, and Wyoming produced twenty per cent. of the total output in 1901, and 37½ per cent. in 1902, and bid fair to increase this percentage.



A Prospecting Drill.

In the Appalachian field when a producer obtains oil he must dispose of it to a pipe-line company, and the custom is to send for an agent or gauger to measure and inspect the petroleum in his tank and run it into its lines, the tanks throughout the field having been carefully measured and a card issued, showing the number of

barrels from top to bottom to each inch of liquid. From his blank-book the gauger gives the operator a " run ticket," sending a duplicate to the nearest general office, as well as reporting the amount by telegraph, keeping the third one himself. The pipe-line company deducts the amount due the owner of the property according to the terms of an agreement on file at the office, known as the royalty, and the next day the producer can secure the cash for his petroleum at the market quotation for the day or hour of his sale, at the nearest home office of the company, from a purchaser for the refining companies, or, if the producer wishes, he can obtain a certificate when his production in the tanks of the pipe-line company amounts to 1000 barrels.

These certificates are made payable to bearer, and are therefore transferable. They are subject to a transportation charge in the district of twenty cents per barrel and a charge for storage at the rate of twenty-five cents per day per 1000 barrels when the price is less than $1, thirty cents when over $1 and under $1.50, and forty cents for all over $1.50 per barrel. They are to be returned for exchange to the pipe-line company within six months after issue, or be subject to a charge of one-twentieth of one per cent. daily thereafter until exchanged. To cover losses by fire or lightning, certificates are subject to an assessment *pro rata* on all oil in the custody of the pipe-line.

What is known as the Texas-Louisiana oil-field comprises the following districts:

In Texas—Beaumont, Sabine Pass, Sour Lake, Saratoga, Dayton, High Island, Columbia, and a few minor districts; in Louisiana—Jennings, Ansa la Butte, Sulphur, Vinton, Hackberry Island, and minor districts.

At the Spindletop Pool, in the Beaumont district, there are some three hundred wells of commercial importance. Enormous output was prophesied for the Texas field a few years ago, some going so far as to say that it would excel the great Baku field in Russia, but these ideas have moderated a little, and the development of oil here is now regarded more conservatively. The Beaumont petroleum is valuable as fuel in its crude state, though in most respects it is inferior to both Pennsylvania and Russian oil, and not valuable for refining.

The rotary process of well-drilling is mainly used at Beaumont, the contracts running from $4 to $4.50 per foot, the contractor furnishing all tools, machinery, labor, etc. About two months are required for the drilling of one of these wells. Con-

siderable care has to be exercised at the time a well is opened on account of the very poisonous nature of the gas that accompanies the oil. It is bad enough to inhale petroleum vapor, which renders a person unconscious, but the combination of hydrogen sulphide which

Manner of Drilling Oil-Well.

A Torpedo.

issues with the petroleum vapor from the wells of Beaumont is almost sure death to one who inhales it. Notwithstanding this danger, the fatalities are very few.

The total production of crude petroleum in the Beaumont Spindletop field, including the oil wasted from wild gushers and from other wells, the local consumption, the oil held in tanks, and the oil

shipped away, from the beginning of 1901 up to January 1, 1903, is estimated at 17,000,000 barrels. The value of well material, tanks, tank-cars, pipe-lines, pumping-stations, refineries, and wells producing, drilling and abandoned, is estimated at about $8,000,000. May 1, 1902, there were 52 abandoned wells, 240 producing wells, and 60 wells drilling; a total of 352—an increase in 17 months of 24 abandoned, 109 producing, and 14 drilling wells.

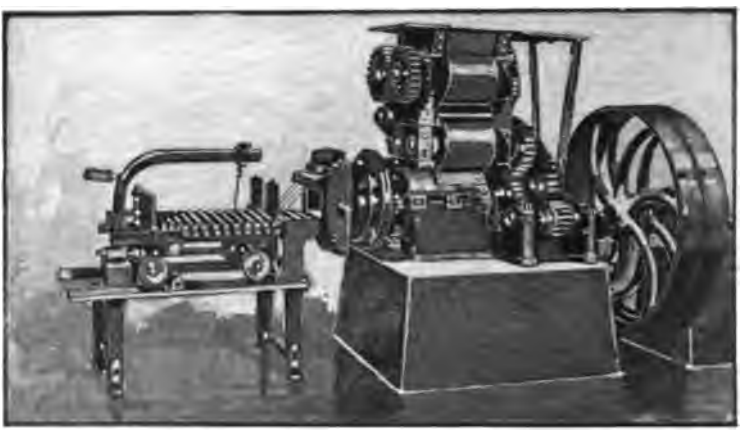
The Kern River field of California has been one of the most sensational producers of petroleum of recent years. In 1902 this section produced two-thirds of the total of nearly 15,000,000 barrels produced by California. In 1903 this field distanced the Texas field, yielding 18,000,000 barrels of the total of 24,340,000 credited to California in that year. The oil land is so large in area that its possibilities are enormous. Most of it was government land that a few years ago could have been secured for nothing by settlers, or purchased at from $1.50 to $2.50 per acre. Between 1902 and 1904 much of it changed hands at from $1000 to even $10,000 an acre. The product sold from this field in 1903 represented interest at six per cent. on $50,000,000, and the amount would have been much more, were it not that the lack of tankage and unfinished condition of pipe-lines caused the waste of uncounted thousands of barrels.

In 1902 a test was made by Lieutenant W. P. Winchell, of the United States navy, on the use of petroleum oil as a substitute for coal under the boilers of a steamship, the Mariposa. The oil used was from the Kern River district in California, and the boilers were those already in use that had been designed for burning coal. The result of the test showed that the usual speed could be maintained, and that there was apparently no greater danger than when burning coal, as no accidents occurred during the trip and no extra precautions were taken. There was a reduction of the force in the fire-room of sixteen men, and the report stated that three more could be dispensed with. This report would seem to settle the question as to the utility of using petroleum as a fuel for steam-vessels; the expense has also been proven to be less, and as a result a considerable number of steamers running from San Francisco are now equipped for oil fuel.

The 1901 report of the Department of the Interior on the petroleum industry states that there were organized in that year 1478 oil-well companies, capitalized at a total of $663,000,000; of these only 556 ever produced any petroleum. These figures show the speculative side of the petroleum industry, and suggest the great amount of money that is sunk in drilling for oil that is never found.

CLAY AND ITS PRODUCTS

THE basis of the brick, terra-cotta and pottery business is clay. This was one of the first materials employed in building, the ancient Egyptians understanding the manufacture of bricks, while the pottery of Peru and Mexico marks the earliest civilization of America. Bricks were made mainly by hand in wooden moulds prior to 1875, but during the past twenty years have been made almost wholly by machines, of which there are three kinds. The wet-clay machines push the material through a cylinder having a reducing nozzle of rectangular shape, which delivers what would be one continuous



French Brick-Making Machine.

soft brick, were it not cut into lengths by cross wires and separated. The stiff-clay machines are designed to produce a heavier and better quality of brick, and the dry-press machines are used for making pressed brick with a smooth and polished surface.

The clay is first ground and mixed in a pug-mill, such as that shown in the illustration. The interior of the case is supplied with rotating blades that cut up and thoroughly mix the clay as it passes through. The augur type of brick-machine is that commonly used, making its product from soft or wet clay. The word augur is descriptive of an interior device having spiral blades like an augur, only vastly larger, which pushes the clay through the machine. As the clay comes out it is cut into bricks by the cross wires, a peculiar

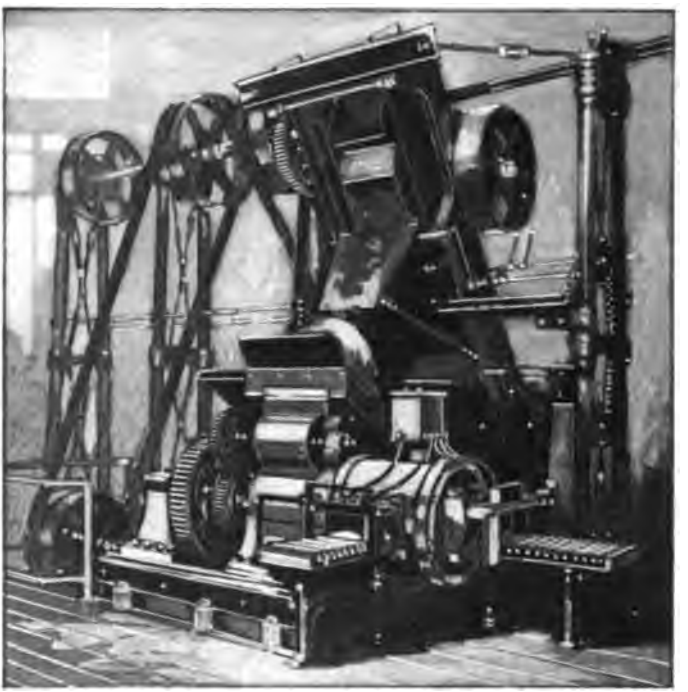
motion is given to the travelling belt, and this serves to separate the blocks, which are then sent to the kiln to be dried.

Bonnot Pug-Mill.

The dry-press moulds several bricks at a time under a heavy pressure, the clay being introduced dry from a grinding-mill. Some

of the dry-press machines are made for forming bricks in various ornamental shapes, there being a much increased demand for these in the construction of modern dwellings.

In 1900 there were 6423 establishments manufacturing clay products in the United States, having a total capital of nearly $100,000,000, and giving employment to 11,000 persons. The value of the product manufactured was $96,000,000, this being more than double what it was in 1880. Of this product $40,000,000 was common brick, $8,600,000 fire-brick, $4,800,000 vitrified brick,



German Brick-Making Machine, with Feeder.

$4,500,000 sewer-pipe, $3,600,000 drain-tile, $2,500,000 pressed brick, $2,000,000 fancy colored brick, $2,000,000 architectural terra-cotta, $1,600,000 hollow brick, and about $8,000,000 minor sorts of brick, tile and terra-cotta. The total of pottery products made from clay was over $17,000,000, of which the largest item was semi-vitreous porcelain ware—cream-colored ware, stoneware and white granite ware coming next.

There was a decrease in the use of common brick during the period between 1890 and 1900, which is attributed to the intro-

American (Bonnot) Brick-Machine.

duction of steel buildings, involving the increased use of cement, and also to the employment of vitrified brick for sidewalks.

Pennsylvania is the leading State in the brick and tile industry, New York being second, and Illinois third. The average price for common bricks in the United States for 1900 was $5.18 per thousand, the lowest figure being $4.23 in New York. Pressed front brick had an average value of $9.

Of the materials used in the manufacture of brick and tile, the item of fuel costs twenty-five times as much as the clay used, while the freight charges paid by the manufacturer are nearly double the

Jeffrey Brick Conveying Machine.

cost for clay. He even pays as much for the sand, coal, manganese, iron, salt, and barium that he mixes with his clay, as he pays for the clay itself. In other words, the clay is but a minor item of expense, amounting to but about three per cent. of the total cost of materials, and but one-fifth of one per cent. of the selling value of the brick and tile! We export a small quantity of brick, tile, and pottery, but import about seven times as much as we send out, the excess being mainly owing to decorated china and porcelain imported for its artistic beauty.

Aluminum is obtained from bauxite, a variety of clay very rich in the mineral. The principal mines are in the south of France, although some bauxite is mined in the United States and in Great

Britain. Notwithstanding France's advantageous position in controlling about three-fourths of the world's supply of material for making aluminum, the United States is the largest manufacturer, the Pittsburg Reduction Company at Niagara Falls being the largest producer. This company in 1903 established a plant at Bauxite, Saline County, Arkansas, where there are large deposits of bauxite ores. Here the ore is ground, and calcined in furnaces to secure the aluminum oxide from which commercial aluminum is produced.

The greatest demand for aluminum comes from the manufacturers of electrical apparatus and machinery. It is also in demand in the metal trade as a substitute for brass and zinc. The metal has been rather overrated, but it has qualities that render it useful for many purposes. It is light in weight, ornate in appearance, and does not easily corrode, being superior in this latter respect to brass, or, indeed, any of the common metals. The notion that aluminum is valuable for the construction of air-ships is an erroneous one, founded on its light weight; but it is not as light as steel when measured by the test of strength. A square foot of aluminum is vastly lighter than a square foot of steel, but a pound of aluminum wire or tubing will not bear as great strains as a pound of steel wire or tubing.

The notion which prevailed a few years ago that aluminum was going to create a revolution in the industrial world has worn itself away. The cost of production is too great to enable it to be used as a substitute for tinware or other common articles and utensils, and in those directions where its use is desirable the demand is not very large. The racing yachts "Shamrock II.," "Independence," and "Defender" were built with deck-plates of aluminum, protected with wood, but they were not satisfactory. Aluminum does not withstand the action of salt water for any length of time. Its use for automobiles is comparatively trifling, and the same is true of cycles. The substitution of aluminum plates for lithographic stones in lithography has made some progress.

The steel industry uses considerable quantities of aluminum, its affinity for oxygen rendering it of value in steel-casting. The most novel use to which aluminum has been put is probably the construction of the dwelling-house, shown at the Buffalo Exposition in 1901. This was twenty-two feet in height, fifteen feet square in ground plan, and had walls, sills, roof, etc., formed of sheet aluminum.

As an alloy, aluminum fills many valuable places in the industrial world. Alloyed with nickel and with silver, ornamental com-

pounds are obtained. Alloyed with tungsten, great tensile strength is secured. Alloyed with zinc, a useful metal results, employed for scale-beams, surveying and astronomical instruments, etc. In this instance about three parts of aluminum to one of zinc usually gives the best results.

Pure aluminum is best for electrical conductors, and manufacturers go to great expense to provide a practically pure article. Absolutely pure metal of any sort is very rare, owing to difficulties of separation in smelting and refining processes.

CHANGES IN SUGAR MANUFACTURE

SUGAR has become one of the most essential articles for the table, and the low price at which it sells is very remarkable, considering the several processes of manufacture. In 1850 the consumption of sugar in the United States was twenty-two pounds per capita; in 1901 it had risen to sixty-eight pounds per capita. The world's production of sugar in 1840 was 1,150,000 tons and in 1900 the total arose to 8,800,000 tons. In 1840 only five per cent. of the sugar manufactured was made from beets, but in 1900 the beet supply was sixty-seven per cent. of the total. While the above figures are given as the world's production, it should be understood that they do not include the sugar made in India and in China, where the manufacture is carried on for local consumption and no record is kept of the product.

The first record of sugar being manufactured successfully in the United States is that of Louisiana, where Étienne Boré, in 1795, established works. Others assisted in growing the cane, and by 1802 the crop of the State was 2500 pounds. The industry advanced slowly, mills operated by horse- and cattle-power being employed for a great many years. By 1850 there were nearly a thousand sugar plantations in Louisiana, and the annual product was over 100,000 tons. In 1861 the crop had grown to 240,000 tons, and the industry was in a fair way to become a great one, when the Civil War broke out and killed it. During recent years the Louisiana business has been revived and is now on a satisfactory basis, though not what it might have been under more favorable circumstances.

The sugar industry of Cuba was large and more prosperous than that of Louisiana, but suffered a decline during the long years of the Civil War between Cuba and Spain, so that the industry was nearly wiped out. If it had not been for these two wars it seems probable that sugar made from the sugar-cane would lead in the markets of the world, but, owing to the strangling of the cane-sugar product by these conditions, beet-sugar gained ground rapidly, obtained a lead about 1895, and now constitutes two-thirds of the world's product. The cultivation of the beet for sugar-making began in France under Government assistance, and extended to Germany, Austria, Belgium and Russia, in all of which countries it prospered with the assistance of bounties.

In 1888 Claus Spreckels established a large beet-sugar factory at Watsonville, California, and two years later he started the Oxnard Beet-Sugar Company, at Grand Island, Nebraska, and later another factory at Norfolk, Nebraska. Since then a number of other large beet-sugar factories have come into existence in the Western States.

Sixty years ago most of the sugar used was sold in an unrefined condition, and even thirty years ago the brown unrefined sugar was the most common article obtained. During the early history of the refining industry, the refined sugar sold for an advance of about ten cents a pound over the raw unrefined brown sugar, and the cost has been gradually reduced until to-day the white

Hauling Sugar-Cane by Electric Railway in Hawaii.

granulated refined sugar sells at so low a price that there is no demand at all for raw sugar. The refiners began to use the vacuum-pan about 1855, the charcoal filter being adopted a little later. Machinery for granulating and reducing the grain was introduced as early as 1848, but the centrifugal machine for separating the syrup was not known until 1860. The polariscope for testing sugar came into use about 1870.

One of the first refineries was that of the Rhinelanders, which was established on William Street, New York. The Havemeyers and R. L. & A. Stewart were among the other earlier firms in the sugar-refining industry. The Havemeyers starting in 1805 in Vandam Street, New York, becoming in process of time the largest refiners in the country. In 1875 there were forty-two sugar refineries in the United States, having a combined output of 25,000 barrels per day. At that date the difference in cost between the raw and refined sugar had been reduced to about three cents. In 1880

the number of refineries had been reduced to twenty-seven, and the competition became so sharp that in 1882 most of these began to work together under trade agreements. In 1887 nineteen refineries were consolidated as the Sugar Refineries Company, with a capital of $50,000,000. In 1891 the company was changed to the American Sugar Refining Company, which in the following year acquired four outside refineries, and now controls the sugar-refining industry of the United States, being popularly known as the Sugar Trust. This company owns several of the largest and most complete refineries in the world, having enormous plants in Brooklyn, Jersey City, Philadelphia, Boston, Baltimore, New Orleans and San Francisco.

Interior View of Standard Beet-Sugar Company's Factory at Leavitt, Nebraska.

In making sugar from the cane, the first process is the cutting up of the cane, which is done by a machine having corrugated rollers that break or cut the grain into short pieces. It next goes to the cane-mill or sugar-mill, which is a large machine having very heavy rollers for squeezing the remaining juice out of the cane. The juice is caught in a tank, and strained and purified by defecation. The purified juice is taken to a series of vacuum-tanks, which have succeeded the old-time vacuum-pans. Here the syrup is boiled, a slight vacuum being maintained in the first tank, and a stronger vacuum in each of the succeeding tanks. This boiling reduces the cane juice by evaporating the water, so that the remainder becomes a thick syrup. This is clarified and cooled in order to separate the sugar.

from the molasses. This is done in a centrifugal machine, made something like a cream-separator, which whirls around at great velocity, throwing out the molasses and retaining the sugar, which is then ready for the refining process.

In refining, the sugar is first dissolved in hot water and treated in what are called "blow-up" pans, as a purifying measure. The sugar and water are then passed through a series of filters containing animal charcoal or bone-black. The next treatment is in a vacuum-tank, where it is reduced much as previously described, and later taken to a centrifugal machine, from which it is taken out as refined sugar in the condition in which it is sold to the public.

In making beet-sugar, the beets are very thinly sliced, and then passed through a diffusing-machine that circulates in water in order

Alvarado (California) Factory of American Beet-Sugar Company.

to separate the saccharine juices from the beet-pulp. The beet-juice so obtained is then subjected to saturation with carbonic-acid gas, after which it is carbonated and allowed to settle. It may then be filtered and taken to the vacuum-tanks, the rest of the process being similar to the manufacture from cane-sugar.

Maple-sugar was a fairly prominent industry in 1860, the United States production for that year being about 25,000 tons, but it has declined rather than grown, and now cuts a very small figure in the sugar trade. Vermont, which is the largest producer, turns out about 5000 tons a year and Ohio about 4000 tons, while several of the other Northern States produce small quantities, mainly for local consumption. It is prepared in very small factories, the sap being boiled in open pans called evaporators.

Sorghum syrup manufacture is a kindred industry carried on in a small way in a good many Southern sections of the United States, the annual product being about 25,000,000 gallons. This is mainly produced in horse-power mills of the crudest construction. The sorghum plant has never received much attention, and it is very possible that if it received the same scientific study and care that have been given to the development of the beet, that its saccharine juices might become of considerable commercial value. The sap of the sugar-maple is perhaps the purest of the natural saccharine juices; the juice of the sugar-cane is of less purity, and sorghum juice has the reputation of being fuller of impurities than either. Yet when these three syrups are made into refined sugar they have similar qualities and value, and lose the flavor peculiar to the plant from which they originate.

The beet-sugar industry of the United States, as reported in the census in 1900, includes thirty-one establishments with a total

Centrifugal Machines used in Sugar Manufacture.

capital of $21,000,000; of these the eight California factories do nearly half the business of the country, Michigan being the second State of importance in the industry. At the time the census statistics were compiled one-half of the number of factories had been in operation but a single year, so that the business was too new to make a good showing of prosperity. The total output of sugar from these factories was about 72,000 long tons of 2240 pounds. It is calculated that on an average ten pounds of sugar were obtained from every 100 pounds of beets, and the price paid for beets averaged a little less than $4.50 per ton.

Previous to 1879 the endeavors to manufacture sugar from beets in the United States had all ended in failure, but about 1899 the Alameda Sugar Company, which had installed first-class machinery in order to manufacture on a larger scale, made a marked success, and this induced others to embark in the business. Owing to the fact that beets are obtainable during only a portion of the

year, the manufacturer is active only during certain months. In order to show how far behind is the United States in the manufacture of beet-sugar, the following table is given showing the number of tons produced in European countries:

The beet-sugar production in the United States has tripled since 1900, the tonnage in 1902–03, being as follows: California. 70,909; Michigan, 57,678; Colorado, 29,643; Utah, 15,625: Nebraska, 7768; Wisconsin, 3463; Minnesota, 3393; New Mexico.

	1899–1900. Tons of 2240 Pounds.	1898–99. Tons of 2240 Pounds.	1897–98. Tons of 2240 Pounds.
Germany	1,798,631	1,721,718	1,852,857
Austria	1,108,007	1,051,290	831,667
France	977,850	830,132	821,235
Russia	910,000	776,066	738,715
Belgium	304,000	244,017	265,397
Holland	171,029	149,763	125,658
Other countries	253,929	209,115	196,245
Total for Europe	5,523,446	4,982,101	4,831,774
United States	71,427	32,471	40,399

2500; Washington, 1518; Ohio, 1339; total, 195,800. During 1903 the number of United States beet-sugar factories increased from forty-two to fifty-six.

The following table of consumption of sugar in the United States during recent years was prepared by the Bureau of the Treasury Department:

Calendar Year.	Refined Product of Imported Sugar.	Domestic Product.					Total.	Consumption per Capita.
		Manufactured from Imported Molasses.	Cane.	Maple.	Beet.	Sorghum and Other.		
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Pounds.
1890	1,257,292	53,282	136,503	25,000	2,800	1,500	1,476,377	52.8
1895	1,572,438	15,000	324,506	7,500	30,000	300	1,949,744	63.4
1897	1,715,607	150	310,537	5,000	39,864	....	2,070,978	64.8
1898	1,708,937	1,700	252,812	5,000	34,453	....	2,002,902	61.5
1899	1,844,642	5,200	160,400	5,000	62,826	....	2,078,068	62.6
1900	1,950,014	7,647	174,450	5,000	82,736	....	2,919,848	65.2
1901	1,932,330	17,977	292,150	5,000	124,859	....	2,372,316	64.4
1902	2,092,657	23,600	296,000	5,325	148,526	....	2,566,108	72.8

While we manufacture less than one-tenth of the sugar we consume, we do refine the sugar that we import, this business being in the hands of the American Sugar Refining Company, popularly known as the Sugar Trust. No particulars of their business are obtainable.

THE FURNITURE TRADE

STUFFED chairs, couches, divans, bureaus, chiffoniers, etc., are comparatively modern inventions. In the Elizabethan era, notwithstanding the rise of literature, hard wooden chairs and settles were the customary seats, straw-beds were the rule, tables were of the severest rectangular patterns, and the names now familiarly used for numerous household and parlor essentials were unknown.

For a century or two the old four-posted bed, with a bottom of cords, was regarded as the height of luxury. A tick full of fresh straw laid on the crossed cords, surmounted by a feather-bed, made a nest in which, with plenty of quilts and comfortables, our ancestors were able to defy the low temperatures that penetrated to their unheated sleeping-apartments. The spring-mattress came in after the middle of the nineteenth century when wire-drawing had become comparatively cheap. The woven-wire spring followed, which, with the hair-mattress, furnishes the acme of up-to-date comfort.

The application of the factory system to the production of furniture has given the public the combination of beautiful and ornamental yet strong and serviceable furniture that may be purchased at moderate figures. The wood shapes that form the basis of most articles of furniture are made largely by automatic wood-working machines that reduce the labor to a minimum. The H. B. Smith tenoning-machine here shown is only one of many such. Nearly all the tenoning or forming of joints, smoothing, and polishing, as well as the simpler sorts of carving, can now be performed by machine, the hand-labor being required simply to put together the parts, adjust the springs, fit the upholstery, and the like. For a description of some of these machines, see the chapter " From Logging-Camp to Lumber-Mill."

The substitution of the factory for the cabinet-maker in the building of furniture may be said to have begun in 1815 when the first power machinery was introduced; by 1825 there were a number of small factories in the United States making furniture in a small way. In 1850 the factories of the country had developed so that they produced $15,000,000 worth of furniture, and employed 37,000 wage-earners. These concerns began with the making of cheap and low-grade furniture, the idea being to undersell the hand-made work of the cabinet-maker. As machinery developed

the factories built better and better goods, and in the course of time began to produce articles and classes of goods which it was impracticable to make by hand, and at the present time the hand-worker

Courtesy Crocker-Wheeler Company.

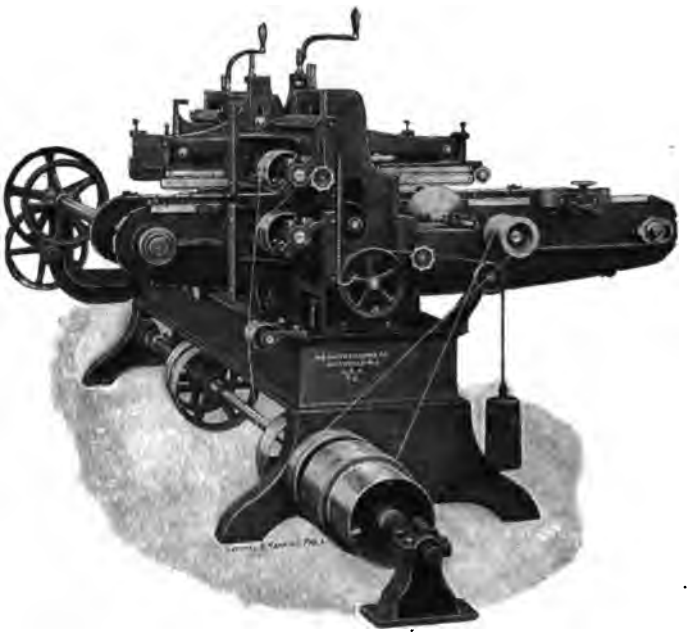
Band Sawing-Machine, as used by Manufacturers of Furniture.

has been driven entirely out of the market, such hand-carving as is performed being done by employees in the furniture factories.

It was immediately after the Civil War that the furniture manufacturers of the United States began to understand the wants of the public and to furnish a good grade of furniture having some

artistic merit. They began to set fashions and styles in furniture and to cultivate the æsthetic. As a result, the business developed with amazing rapidity, multiplying four and a half times between 1850 and 1870, the value of the productions of the latter year being nearly $69,000,000.

Straight-line furniture was in favor during the sixties, and has again come into some favor in 1904 in the endeavor to imitate colonial hand-made tables and chairs. The Eastlake or Early English style became popular largely through the influence of the Centennial



Courtesy H. B. Smith Company.

Double-End Tenoning Machine.

Exhibition in 1876. The Romanesque or Byzantine fad followed, but by 1889 was superseded by the eighteenth-century style, which fashion was set by the exhibitions of furniture in Paris in that year. The ornamental woods used are subject to considerable fashion changes. At one time everything was mahogany, then curly birch and maple were popular, next light oak, and later oak, and so on.

Distinctively American articles of furniture are the bureau, rocking-chair, folding-bed, American form of chiffonier, and most of the combination articles, such as combined desk and bookcase.

The folding-bed, whose object is to economize space, has been

the subject of numerous patents, and is now made in many ornamental forms, so that when closed it imitates a bureau, a wardrobe with a mirror front, or something of the sort. The sofa-bedstead is also made in a considerable variety of forms. The introduction of iron, steel, and brass into the framework of bedsteads has worked a considerable change in bedstead-making within the past decade, and they are so well received by the public that it would not be at all a matter for surprise if other metal furniture came into fashion.

The construction of furniture for business offices, salesrooms, stores, etc., is an important branch of the furniture trade, and very many useful articles have been perfected. The now universal rolling-top desk is produced at a very low price, as are also the many forms of convenient cases for the storing of papers and goods. The "knockdown" or "sectional" or "elastic" bookcase has been the subject of a number of patents, and is made in several ways, the general principle involved being the ability to add to or take from the structure according to the convenience of the user. There have also been important improvements in show-cases, mainly through the introduction of more glass, so that the goods are more easily inspected.

Within a few years upholstering-machines have begun to come into use, some of these performing the complete operation of adjusting and tacking on the material. Of course, these can operate only upon furniture of a specific character, but they are developing rapidly. Many other instances might be cited in which the furniture trade is developing, but the facts are too commonly known to the general public to make it worth while to describe them here.

THE QUARRYING INDUSTRY

It is believed that the first marble quarry in the United States was that opened at Dorset, Vermont, in 1785, which was operated in a small way. About 1800 marble was quarried and sawed into slabs at Marbledale, Connecticut, and two years later at Stockbridge, Massachusetts. The area of marble at Rutland, Vermont, where the largest quarries exist, is about half a mile square, and the marble is found at an angle of about forty-five degrees.

Courtesy Ingersoll-Sergeant Company.

Broaching in Slate with Quarry Bar.

The granite business of the United States dates from about 1820, when work was begun at Quincy, Massachusetts. The granite for Bunker Hill Monument was taken out of the quarry there in 1827. In 1880 the granite output of the United States quarries was valued at $5,000,000, and by 1900 this value was trebled.

About 1835 John Baldwin, later founder of the Baldwin University, quarried sandstone in Ohio and hauled it to Cleveland by ox-teams, gradually establishing a market. The first slate was quarried in Vermont in 1845 by Colonel Allen and Caleb Ranney, whose

quarry is still yielding a fine grade of slate. About 1847 the public demanded slate for roofing purposes, which greatly strengthened the quarrying industry of Vermont.

Ingersoll-Sergeant Track Channeller.

More stone is quarried in Pennsylvania than in any other State in the Union, Ohio being second. Their supremacy, however, comes principally from the quarrying of limestone and miscellaneous stone for road-making. In the quarrying of valuable stone, Vermont

takes the lead. Most of our granite comes from the Eastern States, our slate from Vermont and Pennsylvania, our sandstone from Ohio, and marble from Vermont, Tennessee, Georgia, New York and

A Sullivan Channeller at Work.

Massachusetts. The variegated marbles of Tennessee are principally used for interior decoration.

Common stone is blasted by the ordinary method of boring holes and introducing an explosive, but powder cannot be used in blasting marble, as it damages the handsome white surfaces, though

it may be employed to remove the stone that lies above the marble. Instead of the rock-drill, therefore, the channelling-machine becomes the principal reliance of the marble quarrier. The Sullivan channeller, which is here illustrated, is mounted on a small track, along which it runs, performing its work. The steam-engine and boiler furnish the power, and the gang of cutters seen extending beyond the edge of the track, cuts the channel by a rapid up-and-down motion. The steam is admitted above the gang of cutters, furnishing the force for the cutting blow. Cuts fifteen feet in depth have been made from a single level with the Sullivan machine of the heaviest type. It is built in a variety of forms according to the nature and location of the work for which it is designed. Some are arranged with a horizontal channelling cutter, which may be used for undercutting. A form of bar-channeller, or quarry-bar, is also made, having one or two heavy tubular bars mounted at each end on weighted legs, and bearing on a travelling-saddle the channelling tools. Such a channeller may also be employed as a rock-drill.

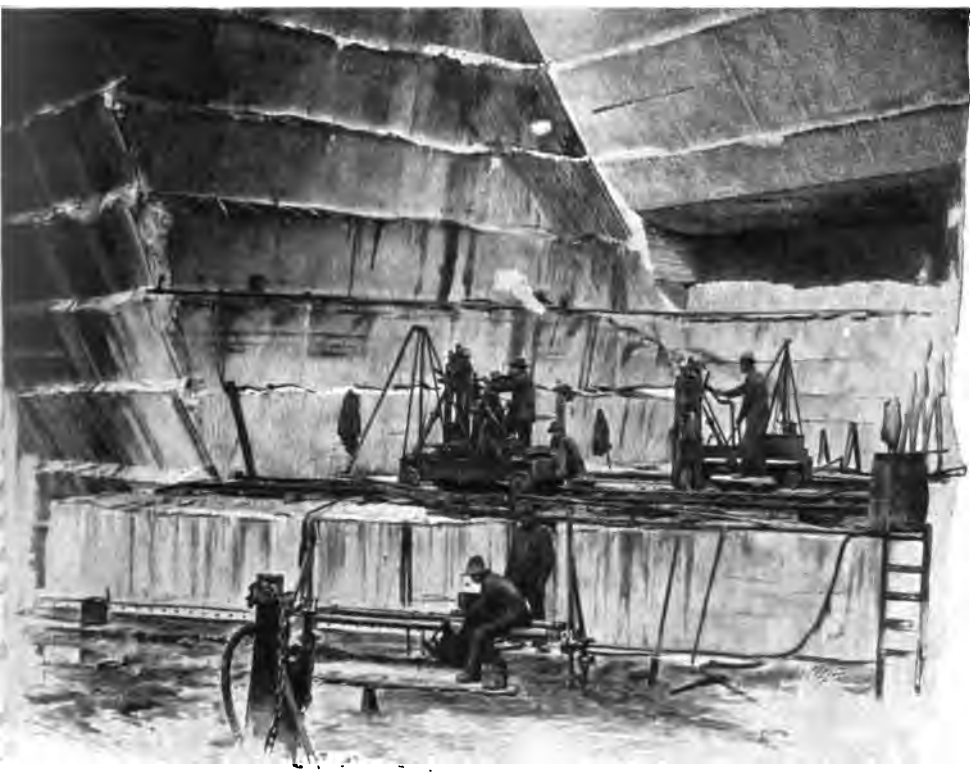
In cutting with a channeller, water is applied to keep the cutters cool, and, if possible, one end of the channel which is being cut is left open, so that the water and mud can run out. A scoop mechanism is provided, however, for taking out accumulations of mud. The hardness of the blow that can be struck with the cutters depends upon the stone, the softer the stone the harder the blow. In cutting the channel the machine runs back and forth on its track, cutting a little deeper at each passage. That it is practicable to cut almost perpendicular walls has been well demonstrated at Niagara Falls, where a cut was made 185 feet deep and only 21 feet wide, though 260 feet long, for the Cataract Construction Company.

A machine used for drilling a row of holes in order to break the tier of rock into blocks, or for some similar purpose, using wedges to split the stone, is known as a gadder. This machine is a sort of cross between a rock-drill and a channeller, being fitted with a drill that can be operated in any direction.

When the marble, slate or other stone has been cut out at the quarry, it is usually hoisted through the medium of wire ropeways, stretched across the top of the quarry. Some quarries are carried down to a depth of several hundred feet, and after a considerable depth is reached it becomes necessary to commence underground mining for the stone. Hydraulic washing has been employed at some of the quarries in order to remove the surface earth and small rocks from the more valuable stone.

Limestone is the most valuable stone quarried in the United States, taken in the order of total value quarried, being followed by granite, sandstone, marble and slate. Of course, as measured by the value of the stone itself, marble takes the lead.

Italian marble was regarded as the best in this country, and was in greatest demand for tombstone purposes up to 1889, about which date the marble of the local quarries secured the largest sale.



Courtesy Sullivan Mfg. Company. **Quarrying in Vermont.**

Since then our improved methods of getting out the stone have enabled American quarrymen to command the home market, although our marble is not as white as the average Italian marble.

The Italian product is quarried mainly in the vicinity of Carrara, which is a mountainous region, and the work there is done largely by hand-labor with very inadequate machinery. In the American quarries every advantage is taken of modern machinery, the channelling-machine having been in use since its introduction by George J. Wardwell in 1863.

UTILIZATION OF FACTORY WASTES AND BY-PRODUCTS

THE writer once heard a gas-engineer assert that he could make illuminating gas at the works at no cost whatever, the by-products selling for a sufficient sum to pay the whole cost of gas-making. Whether or not this was an extreme statement is for those engaged in the gas industry to decide. Certainly, the tar obtained in gas-making, and the coke which is held for sale, and the ammonia collected form a considerable portion of the income of a gas-making establishment.

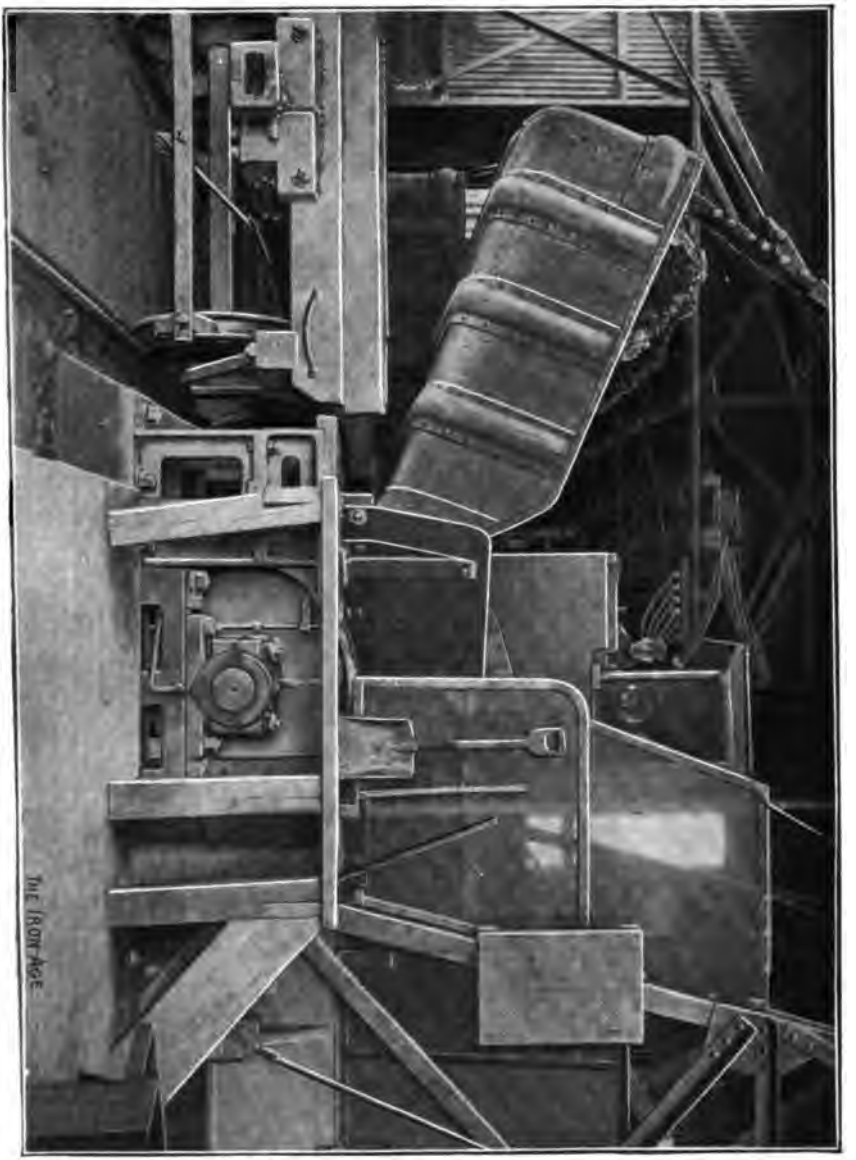
In these days of sharp competition and the application of brains to every department of manufacturing there is no prominent industry that has not given close attention to means for securing the most money for the by-products or waste materials which are produced in a particular line and which may be of considerable value in some other industry.

Take the saw-mill, for instance: its sawdust was formerly allowed to go to waste, being piled in heaps or allowed to float down a stream as an easy means of getting rid of it. Now the lumber-mill and planing-mill are usually supplied with conveyors that carry the sawdust and short ends of wood either to the furnace under the boilers or to an elevated pocket from which they can be later dropped into wagons and sold. The sawdust not only thus furnishes the power for driving the saws that cut the lumber, but also supplies power for a number of modern conveniences in the way of handling lumber in and about the planing-mill.

The sawdust that is sold may be used for the manufacture of acetic acid, wood naphtha and tar, or it may be made up into fire-kindlers with a mixture of resin, or into charcoal briquettes, as is done in the Netherlands. Alcohol has been made from sawdust—pine sawdust being considered the best. It is stated that 220 pounds of air-dried sawdust, containing twenty per cent. of water, have been made to yield over seven quarts of alcohol of a good quality. Sawdust is largely used in the manufacture of clay and pottery, the census returns showing that the manufacturers in that line paid $20,000 for sawdust in the census year 1900. When sawdust was first used for paper-making, the idea was that it could be purchased as a waste product, but wood-paper became such a success that in a short time

the idea of purchasing sawdust was wholly abandoned, and the paper manufacturer is now one of the largest consumers of lumber.

Courtesy The Iron Age.



View in Cement Manufactory.

The most conspicuous article of waste in the iron and steel industry is the slag from the furnaces, this being a mixture of lime-

stone and iron ore, formed chemically in the blast-furnace, and of no value to the iron manufacturer. A few years ago it was estimated that the cost of removing the waste slag from the furnaces of England was $2,500,000 annually. Since this slag has come into use for the manufacture of bricks and slag-cement, the iron manufacturer has been considerably relieved, and the probabilities are that the increased use of slag-cement will make it possible for the iron manufacturer of the future to at least get rid of his slag without expense.

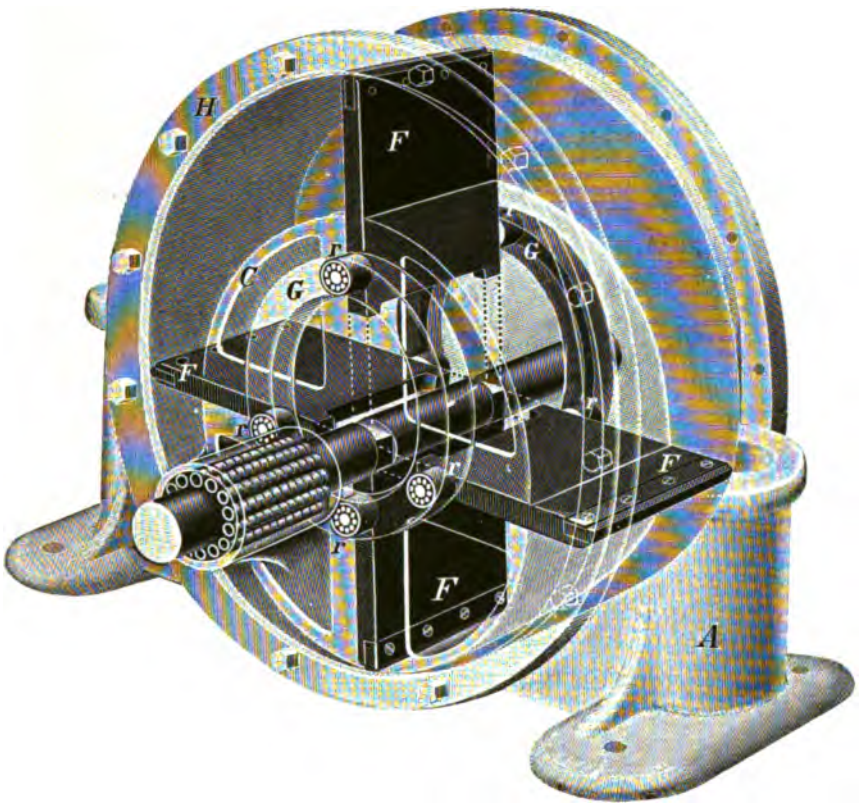
In Germany the waste gases of the blast-furnace are used for operating gas-engines. It has been calculated that if all the blast-furnaces of Germany utilized their waste gases in this way that there would be a total saving of $10,000,000 a year. The reason why this is not done in the United States is because our principal iron foundries are located in the natural gas region, and therefore could not secure the same economy.

Scrap iron and steel, including the waste at the iron-mills, old machines thrown out as junk, and the like, are regularly used in the blast-furnaces for making over into pig iron, and we even imported about 50,000 tons of foreign scrap iron and waste every year.

A valuable by-product in the manufacture of paper is the soda that is recovered. The alkali is prevented from going to waste by the evaporation of the waste liquors, and the burning of the residuum, which produces a carbonate that can be causticized and prepared for reuse. Before paper was made so cheaply from wood, there was considerable adulteration of rag-papers with pulp made from old newspapers, but since the price of wood newspaper came down to two cents a pound, the saving by introducing pulp from old newspapers has been so trifling that it has been almost abandoned. It is used, however, to some extent as a filling in the manufacture of paper-board and box-board.

In the woollen industry the principal wastes are rags and wool grease. The rags are made over again into wool the same as raw material, while the wool-grease finds a sale in various quarters. According to "Industrial Organic Chemistry," a ton of raw wool will furnish about 300 quarts of yolk solution (which is principally wool-grease, and has a value of $3.75). This can be extracted at a cost of sixty cents, yielding a carbonate of potash and nitrogenous carbon that are very valuable in the manufacture of yellow prussiate of potash. There are numerous other minor industries that make use of the grease and potash obtained from the wool. The grease

serves as a base for ointments and toilet preparations, and is also valued as a dressing for leather and for mixing with certain lubricating oils. Nevertheless, it appears by the last census returns that two or three million dollars' worth of wool-fat and potash are still allowed to run to waste by the wool producers of the country. The most of this could be saved by establishing degreasing plants



The Reichhelm Blower, for Ventilating, etc.

at the principal points where wool is shipped. The "degras" used in the leather industry is simply brown wool-grease, though the term is also applied to what is known as "sod oil."

In cotton-mills the waste that is too short for spinning is made into batting and wadding, and is also sold for machinists' use in oiling and wiping machinery. Cotton-seed, which was once itself a waste, and which now yields a valued oil, is worth thirteen per cent. as much as the cotton crop of the country. Its waste is now divided into linters and hulls. The former is used in making mat-

tresses, felt hats and pillows, while the hulls are used as a cattle food.

Meat packers secure a number of valuable by-products from the slaughter-house, a considerable portion of the animals going to the manufacturers of soap, glue and fertilizers, while the bones are made up into knife-handles and a variety of small articles imitating ivory. Many of the hoofs go to the button manufacturer, while black hoofs are valuable to the manufacturer of cyanide of potassium, which is used in the extraction of gold. Neat's-foot oil is extracted from the feet, and a number of other special oils are also obtained. Calves' brains are in some demand by the medical profession for the cure of several nervous disorders.

The manufacture of oleomargerine and other substitutes for butter from beef fat is an industry so well established that it is hardly thought of as employing what was formerly a waste product, yet there was a time when a great deal of beef suet was thrown away. Glycerin is another important article made from fat, both animal and vegetable. The blood of slaughtered animals is purchased by tanners, calico printers and sugar refiners. From glands and membranes are obtained pepsin, ingluvin, thymus, thyroids, pancreatin, parotid substances, etc. The brewers' isinglass is also a product of the slaughter-house.

Waste bits of leather may be moulded and thus utilized in a number of ways, even paving and railway ties having been made therefrom. A process has been devised for making boot and shoe heels of leather scraps, and the inner soles of cheap shoes are sometimes made of this pressed scrap leather. Such leather as the shoemaker cannot possibly employ is turned over to the glue-maker.

Gas-tar, the principal by-product in gas-making, is of great value to the manufacturer of dyes, and is used in medicines and disinfectants, and also for the production of a saccharine substance that is several hundred times sweeter than sugar. The dye-house would hardly know how to do business in these days without the products obtained from gas-tar or coal-tar. Naphthalene, which is one of the products that was formerly considered a nuisance by the gas-maker, is most valued in the preparation of dyestuffs, while the aniline, also obtained from gas-tar through benzol, is universally known as a most productive source of coloring matter. The madder industry of Europe has been very largely destroyed by the manufacture of alizarin, another of the by-products of tar. Artificial indigo, that seems quite as good and is cheaper than the imported article, is obtained by a synthetic process from coal-tar. Taken

altogether, the coal-tar color industry, which is based entirely on this by-product of gas-making, now bids fair to supplant dyewood extracts, the former having the advantage of giving superior results and being more easy of application.

While coke production is the basis of the tar-color industry, it also affords a source of ammonia, and as the demand for ammonia increases faster than the supply, a considerable quantity is obtained as a by-product in gas-making, and finds a ready sale.

In the manufacture and refining of asphaltum, sulphuric acid is obtained, also carbonic acid, boracic acid, bluestone, and epsom salts.

Old rubber is now often devulcanized and desulphurized by steam heat, being thus brought to a condition where it can be used again as rubber by mixing with new material, and is quite satisfactory for such purposes as boot-heels and heavy soles.

The mash or exhausted grain of the breweries is sold for cattle-food, and has considerable nutritive value, being best when mixed with hay. It is estimated that the breweries of the United States dispose of about 300,000 bushels of this exhausted grain every year. There are about 25,000 tons of similar waste produced in the manufacture of hops in the United States, and as no use has been found for these, the information is here given to the inventive reader as an opportunity that will certainly bring money to the man who can find some good use for them.

Among minor savings of waste may be mentioned the scraps of tin remaining after stamping out boxes or cans, etc., which scrap is made up into sash-weights and similar articles; mussel-shells, which were formerly thrown away, are now valued by the button manufacturer; broken glass is being used as a building material, being ground, devitrified, and made into an artificial stone; sifted ashes have also been used in the manufacture of artificial stone in Germany; the once useless corn-pith now has a value as cellulose for lining the armor of a battle-ship; an oil is obtainable from corn (such as comes as waste from breweries and distilleries) which is capable of being vulcanized and being used as an adulterant for rubber, etc. Time and ingenuity seem able to make from every waste a product of some commercial value.

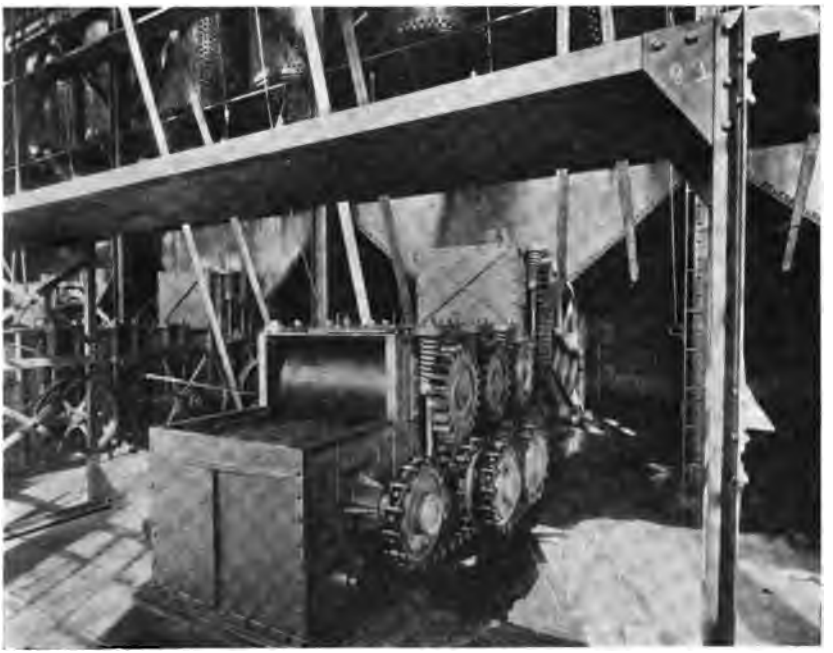
GARBAGE AND WASTE MATERIAL

THE term "garbage" is very comprehensive, but it has come to have a restricted use covering the scrapings from the dinner-table and kitchen refuse made in preparing food; in other words, those animal and vegetable substances that accumulate in a household and which tend to ferment or sour, so as to become a nuisance if kept for any length of time. In the broader and more common usage it includes also ashes, street sweepings, and any form of rubbish. There are no official statistics in regard to garbage disposal, but Messrs. Winslow and Hansen, of the Massachusetts Institute of Technology, compiled in 1902, for the benefit of the American Public Health Association, of Washington, returns from 155 out of the 161 cities of the United States having populations of over 25,000. It was found that eighty-two per cent. of these cities had regular systems of garbage collection, a small majority of them performing the work by a branch of the city government and the remainder by contract with private parties. These figures demonstrate that practically all the large cities of the country have come to recognize that it is a municipal duty to collect garbage, refuse and ashes accumulated by the citizens. From the same source it is learned that more than two-thirds of the cities included in the returns separate the garbage and ashes, many of them making a still further separation, as of combustible wastes. The ashes are usually disposed of by dumping, to fill in land, but in a few cases they are cremated. The garbage proper is disposed of in the following ways:

	No. of Cities.
Dumping on land	44
Feeding to live stock	41
Cremation	27
Reduction or utilization	19
Plowing in or using as fertilizer	18
Dumping in water	14
Irregular disposal by private parties	11
Burning on dump	9

The number of methods employed would indicate that no best means has yet been discovered for disposal. The method followed by the greatest number of cities—that of dumping on land—seems to be the very worst from a hygienic point of view. The feeding

of garbage to stock seems to the writer to be the most satisfactory means, and usually yields a slight revenue to the city adopting this method. The pig is apt to be the animal favored, and a number of successful pig-farms are run on kitchen garbage or swill purchased from near-by cities, the animals appearing to be quite as well as when fed on more delectable foods. The practice has been largely disapproved of, however, though it has found a few strong advocates, as Dr. Chapin, of Providence, Rhode Island. The writer became converted to this system by observing its operation in Salem, Massachusetts, and studying the results at the pig-farm.



Courtesy Scientific American.

A Garbage Press.

Using garbage as a fertilizer is well thought of, but seldom practised, because the expense of transportation is generally greater than the value of the garbage to the agriculturist. Cremation seems to be the plan that meets with the greatest public favor, and which is adopted wholly or partially by most very large cities; but the cost of burning is considerable, the lowest figure being that of Allegheny, Pennsylvania, which was given at twenty-five cents per ton before it was abandoned, and the highest figure being in New York City, where it costs three dollars per ton; probably the average cost is over a dollar per ton.

In New York city the care of garbage devolves upon the Department of Street Cleaning. Here the refuse is divided into four classes—garbage, ashes, street-sweepings and rubbish. Householders are obliged to deposit their waste in separate packages, ashes going into one can, garbage into another, and newspapers and other rubbish into the third. It required a large amount of education before the public became accustomed to separating its garbage in the manner desired by the department. First, notices were printed in the newspapers, and then circulars were sent to every citizen,

Courtesy Scientific American.

Unloading a Garbage Scow.

this being followed up by personal visits from policemen, who explained to the people that they were liable to arrest if they did not follow the directions of the department. When the garbage was not properly divided the department would refuse to carry it away, and if this did not conquer an obdurate householder arrest was resorted to, followed by a fine, until the public began to understand that it was necessary to so divide the refuse, and that the ordinance to that effect would be enforced.

The New York Street Cleaning Department uses steel-bodied, water-tight carts, having canvas covers. These travel daily from

house to house, emptying the garbage-cans that are set out on the sidewalk. These carts deliver the garbage to the scows of the Sanitary Utilization Company, to the amount of over 600 tons daily. In 1902 New York began to dump its refuse on a shallow spot off Rikers Island, but so much garbage was dumped with the ashes and refuse that it became a public nuisance, and the work was stopped by the courts. Dumping was resumed there later, however, only ashes and unobjectionable material being used as filling, and the island is being built up in a way that may be valuable.

The Street Cleaning Department of New York has recently built two incinerators for burning up such rubbish as is not salable or which might be contaminated with disease, as old bedding. The ashes obtained from this burning are rich in potash and ammonia, and are used to nourish the trees in the parks and are also sold to soap manufacturers.

It was formerly the custom to carry New York's garbage out to sea in scows, dumping it at a distance from land, that it might become food for fishes; but so much of it was washed back upon the beaches, becoming a general nuisance, that this method was stopped. The Sanitary Utilization Company now carries the garbage to Barren Island, where it is first treated in a retort for eighteen hours with live steam at eighty pounds' pressure, and is then taken to large hydraulic presses that separate the fluid portion, called tankage, which is allowed to drain off from the solid portion, which has some value as a fertilizer. The garbage is unloaded from the scows by metal belt conveyors and carried direct to the retorts. The top of the tankage is mainly oil, which is skimmed off, clarified, and used for various commercial purposes; the remainder of the tankage is mixed with brown phosphate rock and forms a good fertilizer, being rich in ammonia.

The above is known as the Arnold method of garbage reduction; there are other processes, as the treating of the garbage in lead-lined tanks with sulphuric acid, after which steam heat is applied. Ashes, when in good condition and free from fermenting garbage, have some little value in most localities for filling land. They sell in many cities for from twelve to eighteen cents per cubic yard. The carting of ashes in New York City has been rendered much easier because of contracts made with the surface trolley lines. Special cars made to carry ashes are filled by the department and run on the trolley line at night to salt marsh lands in the suburbs, where they are dumped, this system doing away with the nuisance of ash-carts travelling through the city and blowing dust in all

directions. In using ashes to fill in land at Rikers Island a belt conveyor is employed and the ashes are thrown into convenient piles. These are afterwards levelled after the method used in hydraulic mining, a powerful stream of water being thrown from a hose so that the ashes are spread out and evenly distributed.

An important part of the collection of rubbish of New York City consists of newspapers, of which some twenty-two tons are collected daily. The street-sweepings, which amount to a daily average of 1600 sacks, are delivered to the railways, being desired by them for use on the top of embankments, because the material forms a good basis for a growth of grass.

Courtesy Scientific American.

View in Baltimore Garbage Reduction Works.

The rubbish collected with garbage includes a variety of old trash, as bottles, broken furniture, old bedding, old clothes, kettles, cans, old shoes, sweepings, broken ornaments and small articles, and the thousand and one things that people throw away when they have outlived their usefulness. The men who handle the rubbish could tell a story as to what becomes of all the pins, and occasionally a little stray silverware or something valuable turns up. A cylindrical sifting-machine at Barren Island was found blocked on one occasion, refusing to do its work, and on examination it was found that nearly all the holes had been stopped by an accumulation of hairpins. At the office of the Sanitary Utilization Company at

Barren Island is exhibited the remains of a one-dollar bill which was recovered from the solid products of one of the hydraulic presses, thus narrowly escaping being used as a fertilizer.

The city of Baltimore has an up-to-date plant for the reduction of garbage. The tank-wagons that make the collections from the city are dumped into scows that are towed to the reduction works. These scows are emptied automatically by endless conveyors, which brings the cost down to the lowest notch. The plan includes twenty-eight digesters, each of ten tons' capacity. The garbage placed in these digesters is hermetically sealed, then steam is turned on, em-

Courtesy Scientific American.

View in Baltimore Garbage Reduction Works.

ploying a pressure of about one hundred pounds and a temperature of 200 degrees, for the purpose of sterilizing the material. A roller press is employed to separate the solid from the liquid material, this press being one of the largest ever built, with a capacity of ten tons per hour. It operates almost wholly without any attention, squeezing out the moisture, which flows into tanks or catch-basins. From the top of these basins the grease is secured by pumping and sold to soap manufacturers. Owing to the sterilization the solid matter obtained is singularly pure and free from odor. A fertilizer-plant is being constructed in connection with these garbage-works and will be in operation the present year, 1904.

A committee of the American Public Health Association appointed to consider the best means of disposing of garbage and refuse, reported, a few years since, generally in favor of house-to-house gathering in covered carts or wagons, and that such collections are best made daily during the summer months, and in all large cities at least two or three times a week all the year round. In smaller places the practice of collecting once a week is the common one. The committee expressed the opinion very strongly that even in sparsely settled sections, as far out in the suburbs of cities, collections should be made at least three times a week in the spring and fall, and not less than twice a week in cold weather. If left for a longer period, garbage becomes a nuisance, often detrimental to public health.

The statistics collected by the committee went to show that the quantity of kitchen garbage and combustible refuse is greater per inhabitant in America than in England, and in England it is greater than in Germany. The amount of organic matter in American garbage is greater, and it also contains more moisture, and is therefore harder to dispose of by burning than in foreign cities, especially as the garbage of the latter contains much half-burnt coal.

The committee found that in nearly all European cities the garbage and dry refuse, including ashes, were all mixed together and removed without any effort at separation. In American cities the tendency to separate the refuse increases with the size of the city. The fact that the kitchen refuse or swill is of some value for feeding to pigs, and that there may be recovered from the garbage a fair percentage of grease and other material suitable for manufacturing fertilizers, has caused many cities to sell or endeavor to sell their refuse at a profit. While a portion of the expense can be met in this way, no real profit has ever been made from the collection and disposal of garbage. The committee were of the opinion that the burning of garbage would continue to increase, and that the English form of furnace for this purpose was rather better than the American. The furnace referred to has a sloping ante-chamber, where there is a preliminary drying and heating of the garbage, and this seems to result more economically than where it is thrown into the furnace in a moist condition.

Large cities commonly dispose of their sewage by leading it into an adjacent river, where it is supposed to be more or less purified by natural processes. The system answers very well where the city is not too large and the river has a large flow of water. In the case of the city of London, however, the Thames proved entirely

inadequate a number of years ago to the task of carrying off the city's filth. The nuisance was abated by carrying the outlet of the sewers some fifteen miles down stream, but after a time this was found insufficient, and the sewage is now subjected to chemical treatment and sedimentation before it is allowed to flow into the river. This treatment consists in straining the sewage and treating the matter retained by the screens with solutions of lime and sulphate of iron. A portion is then allowed to run off into the river, while the heaviest part, known as sludge, is sent out in tank-steamers to the ocean.

The city of Chicago solved the problem of getting rid of its sewage by building the now famous drainage-canal from Chicago to Lockport, a distance of twenty-eight miles. It was found that the emptying of the sewage into Lake Michigan resulted in the polluting of the shores until the nuisance was unbearable. The sewage is treated before entering the drainage-canal, which is also used as a ship-canal.

As cities grow larger the problems of disposing of unwholesome sewage and refuse become greater. The world is only just learning how to take care of such matters with a due regard for sanitation. Doubtless, the great cities of coming generations will use vastly improved methods over the comparatively crude means that have been here described.

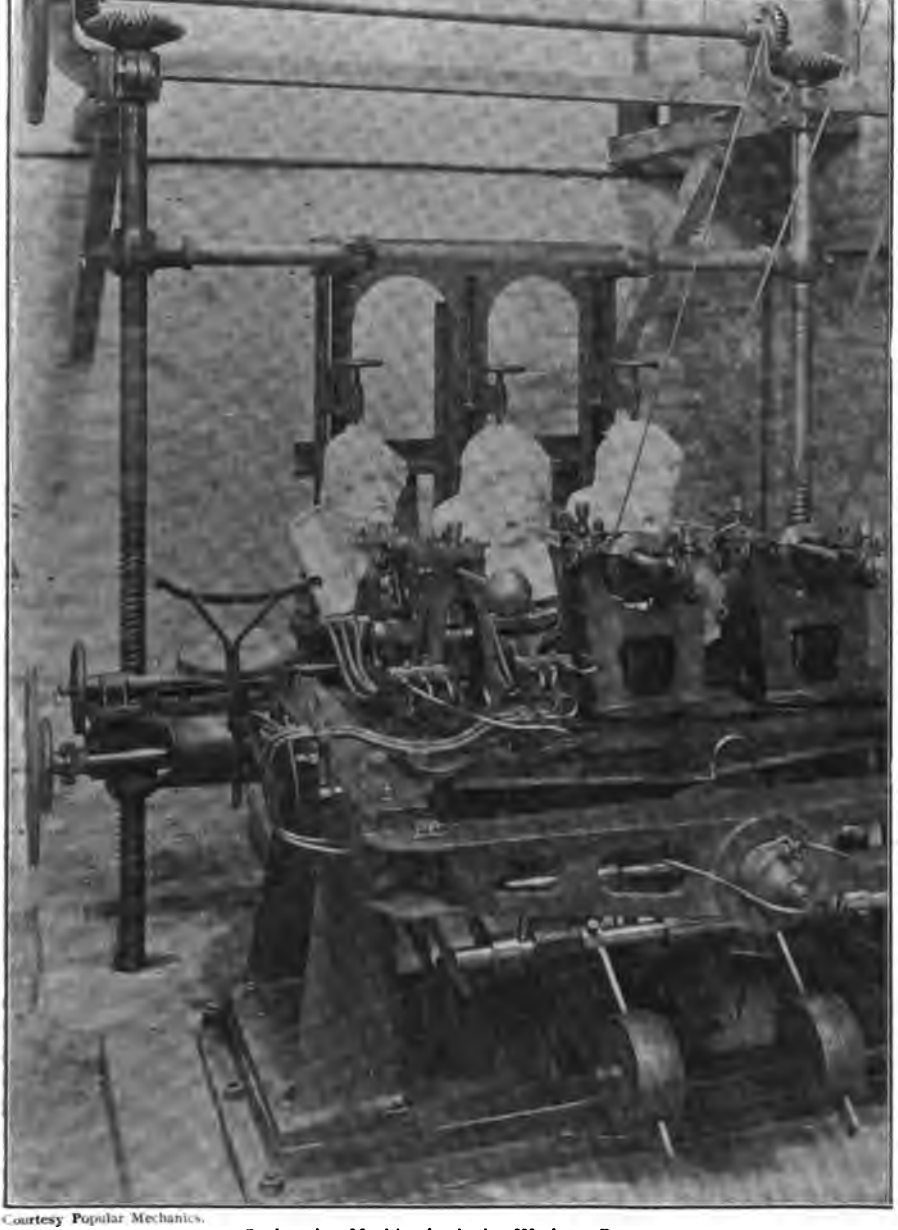
THE "trackless trolley" is the name given to a new form of vehicle that comes half-way between the automobile and the trolley car. The illustration shows one that is doing business as a bus in Scranton, Pennsylvania. It rides easier than the ordinary trolley car and can do something in the way of turning out when it meets other vehicles. The power required for its operation is considerably greater than for a trolley car, but there is no track to be laid or

Courtesy Electrical World and Engineer.

Trolley Bus at Scranton, Pennsylvania.

kept in order. A similar system is in use in several European towns. The use of unusually long trolley poles results in reduced danger of losing the wire by reason of the vehicle running to one side. Further protection against this annoyance is obtained by the double poles and the method of attaching the wheels. The writer believes that Thomas Cummerford Martin, of New York, was the first to suggest this form of vehicle about 1894, but it has made slow headway in public favor, though there are many things to recommend it.

The human figure reproduced in marble is considered the highest type of the art of statuary, the sculptor ever having ranked with the artist in oils, and often commanding much higher prices for his work. The most artistic and difficult part of the work of a sculptor



Courtesy Popular Mechanics.

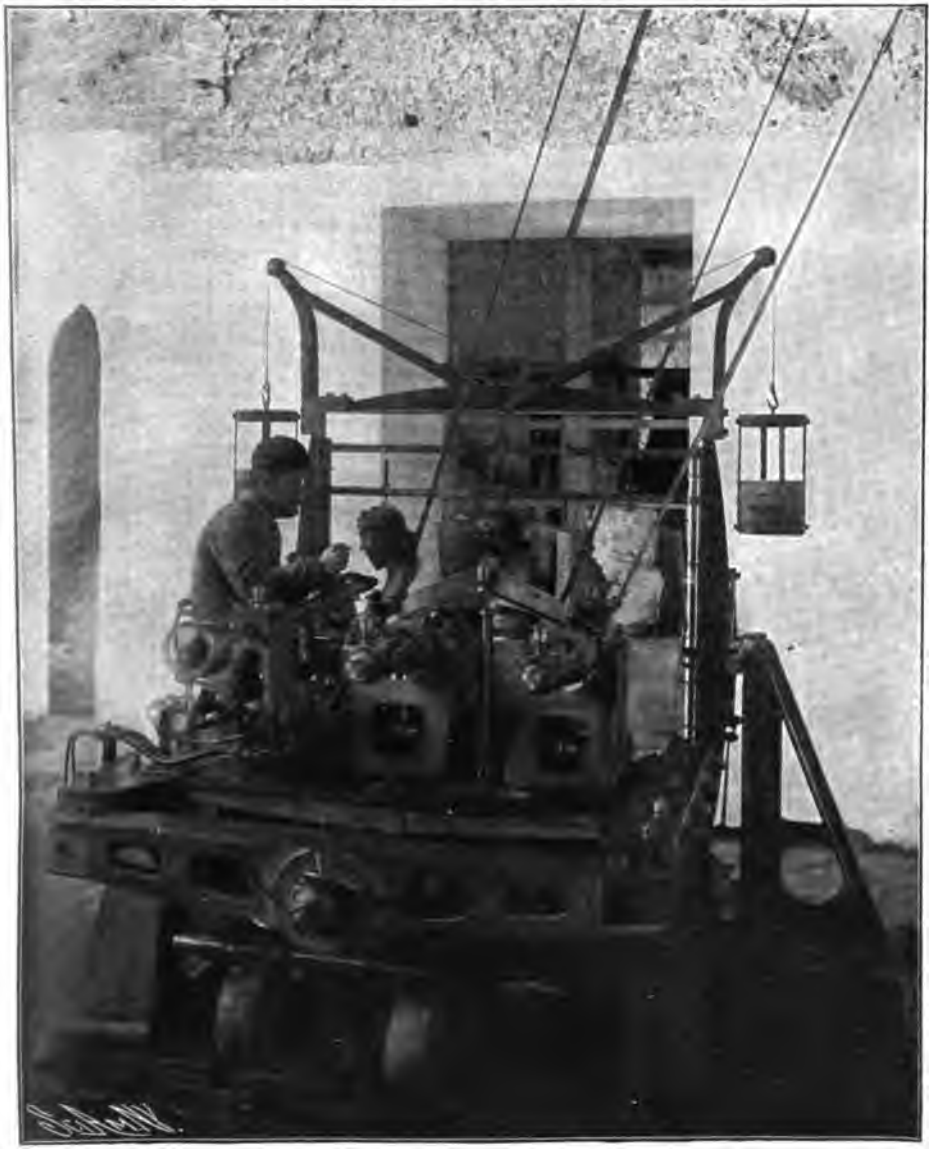
Sculpturing Machine beginning Work on Busts.

consists in forming the clay model, which is afterwards copied in marble. Upon a rough wooden framework the artist piles his clay, moulding it into the proper form with the simplest tools and often with his bare hands, guided by his eye and judgment. The clay used is similar to that employed for making common white stoneware. The true artist has to improve upon his model rather than to slavishly copy it; he is also obliged to make some slight mechanical differences in order to produce the desired effects, for, like the artist in oils, it is the effect that he seeks, and by which he will be judged.

When the soft clay is shaped to the sculptor's satisfaction, plaster-of-Paris casts are made therefrom in order to preserve the work, for the clay is perishable. A number of casts or parts are usually necessary in order to secure an entire mould that will surround and reproduce all portions of the clay figure, and which can be taken away without injuring it. These pieces or casts can then be fitted together to form the mould, which can be filled with a very fine grade of plaster of Paris, which, on becoming hardened, is a reproduction of the clay model in more solid and durable form. It is from the plaster model so made that the work on the marble is taken. The man who reproduces the model in the marble may be and usually is a skilful man, but he is not ranked with the artist who makes the clay original. The plaster model is set alongside the marble which is to be carved, and a pointing instrument is used to fix the main lines that are to be cut away in the marble. The pointer is so designed that the block may be hewn away, or a hole may be bored to any point indicated, with the assurance that the cutting will not go below the surface of the figure to be hewn. By this mechanical means the figure is roughly formed in the marble, the pointer having located numerous parts accurately, so that the artist can depend upon his eye to guide him in carving between the points. He has merely to copy exactly what he sees. When the marble comes back to the artist who made the original clay model, he puts on those finishing touches that remove all suggestion of immobility, and constitute the difference between the work of the copyist and the originator.

One by one the arts give way before the progress of mechanical ingenuity, and the field of the sculptor has not been exempt. An Italian by the name of Bontempi has invented a machine for reproducing a model, as a human head, or anything else that it is desired to represent in marble. In order to produce a statue of a great man, it is no longer necessary to employ some talented sculptor

in building a clay model, occupying months of time and requiring great skill and long experience, and to follow this up with months



Courtesy Scientific American.

Sculpturing Machine Making Finishing Cuts on Busts.

of labor in boring and chiselling the marble. Now the great man has simply to sit in front of the mechanical sculptor while

a pointer takes a pattern of his face, and guides a machine that cuts the marble. This wonderful machine will make two or three marble statues or busts as easily as one, about seven hours' work being sufficient to produce one or more good busts.

It was exploited in London by A. Conan Doyle in 1903 and attracted much attention. For making two busts at once, two rapidly rotating cutters are made to operate on blocks of marble, under the guidance of a pointer that is drawn over the features of the model. These cutters grind away the marble very rapidly, pulverizing it so that it runs away with the cooling water used in a milk-like stream. The exhibition machine which is here illustrated cost only

United States Life-Saving Station, Macatawa Park, Michigan.

$2500. The operator is not required to possess any unusual skill, as the machine will positively duplicate the model. By this means it is thought that the world's famous statues will hereafter be reproduced in marble instead of in plaster, so that the leading art galleries of the world can have more perfect imitations than they now possess.

The principle of this machine is quite similar to one devised in the United States about ten years ago for carving gravestones, monuments, etc., and making surface ornamentation in stone and granite. The Italian machine does much finer work, however, reproducing every wrinkle or dimple with minute accuracy. In doing

the coarser work of roughing out the statue coarse cutters are used, finer ones being substituted for doing the final cutting. After the machine has done its work it is only necessary to sand-paper the bust, when it is ready for the market.

The reproduction of statues in plaster of Paris is performed very much in the manner roughly outlined as used in making a plaster model from the clay model, but when it comes to reproduction in bronze, the work to be well done requires a great deal of technical as well as artistic knowledge. It is claimed that bronze casting has deteriorated in America owing to the work having been placed in the hands of ordinary founders, who treated it the same as common metal castings, using sand and loam moulds that failed to give very sharp results, losing the accuracy of minor details. In preparing to cast in bronze, in order that the figure may be hollow, a rough core has to be formed, and around this are placed the parts of the mould that have been modelled on the lines of the statue. As has been said, sand-moulds are objectionable in that they do not reproduce a surface with perfect accuracy, but a mixture of plaster of Paris and brickdust ground very fine has been found to give good satisfaction, although such a mould is so fragile that it has to be supported with iron embedded in its mass. Of course, the making of such moulds is tedious and requires the utmost care as well as the most thorough drying. When ready for casting, the mould, carefully bound with iron hoops, is embedded in a pit of sand, weights being laid upon the top to prevent any rising because of the entrance of the molten metal. A pour-hole having been provided for the molten metal, and also smaller openings for the easy and perfect escape of the air, the hot metal can be run into the mould, and if the work has been done properly will reach every part of it. A bronze cast made in this way will reproduce a statue almost perfectly, but can be used but once, as it comes off from the cast in dry dust. Such a casting requires some hand-finishing to get rid of minor imperfections and efface sprues and joints. Sometimes artificial means are then employed to color the figure, giving it an appearance of age, but if the bronze is a correct mixture, as ninety-one parts of copper to nine parts of tin, time will give it a better color than anything else.

The machine oil painting is not nearly so good or artistic as the machine-made statue, but it finds considerable sale in the cheaper so-called art-stores. These machine-made paintings are produced in the following manner: A row of perhaps fifty canvases is placed around the walls of a room at a convenient height for painting. A

good painting being provided as a model, an artist takes a can of paint, mixed to the sky-color used in the picture, and going from canvas to canvas daubs it on each one at lightning speed. He follows this up by applying other masses of color, one at a time, to each canvas, until all are covered with a coarse imitation of the original picture, about the only merit being that the colors are carefully mixed, and therefore very closely approximate the original. The finer touches are then put on, a little at a time on each picture, as the artist never stops to mix new tints or colors, except after making the entire round of the room. In this way a

Courtesy Electrical World and Engineer.

Reid's Apparatus for Obtaining Electricity Direct from Coal.

clever man will finish the whole fifty pictures in perhaps two weeks' time, so that the manufacturing cost of painting them is only one to two dollars each, according to the value of the artist's time. Such pictures, viewed from a distance of about twenty-five feet, are hardly distinguishable from really good paintings, and those who have never learned to appreciate the fine qualities of oil paintings often fail to see any difference at all between them and the really great productions.

For the last half-century numerous inventors have tackled the problem of securing a current of electricity direct from coal without the intervention of a steam-engine and all the cumbrous mechanism involved by present methods. Some inventions in this field have

been very ingenious and have attracted wide attention. One of the simplest as well as one of the oldest methods proposed is the use of what is known as a thermo-electric couple, which is made by joining two or more bars of metals that have different ability to conduct electricity. If a flame be applied to the junction of the bars, in alternation with a cooling arrangement, an electric current will be set up in a wire connecting the outer ends of the bars. By this system an electric current can be secured directly from the coal, but the current is so small as to be valueless for commercial purposes.

The most recent as well as promising invention in this field is a fuel-gas battery devised by James H. Reid, of Newark, New Jersey. His method consists in conducting the fuel-gas into a porous chamber that is impervious to a liquid, though permitting the escape of gas. He maintains a heated liquid electrolyte at the opposite face of the chamber and supplies oxygen to the heated electrolyte, providing conductors for the electricity that is developed to carry it from the porous chamber and from the liquid electrolyte. The electrolyte employed is composed of sodium hydrate, calcium chloride and iron oxide, being heated to a temperature of 390° F. Penetrating into the electrolyte and insulated from the iron vessel are hollow electrodes made of carbon; these latter are of positive polarity, while the iron vessel is negative. Fuel-gas being forced into the hollow carbons, the theory of the machine is that it percolates through the porous walls of the carbon so that the carbon and hydrogen of the gas, uniting with the oxygen in the electrolyte, result in the production of an electric current, which continues as long as the gas is supplied.

With the sixty horse-power machine illustrated, the inventor claims to have developed an electrical horse-power for every five feet of gas consumed. It will be interesting to observe the progress of this invention, and, whether it is successful or not, it may point the way for a commercial machine of some sort that shall give the world electricity direct from coal.

The Washington Monument is justly regarded as a remarkable construction of stone, but there exists in Halsbrucke, Germany, a factory chimney that rivals it in height, and is certainly more remarkable in that it is a purely commercial structure. It is 460 feet in height, and being located on high ground is a conspicuous object. The most peculiar feature of its construction is that it is built of hollow bricks, specially formed, so that the outer ends of the bricks are slightly broader than the inner ends, thus producing perfect

joints. No one would think of building such a chimney in America of anything but steel, and it reflects great credit upon the German engineers in charge that they were able to produce so large a structure of so light a material as hollow brick. For use in a chimney, brick is better than steel, as the thicker walls tend to conserve the heat, thus producing a better draft.

Probably the largest smoke-stack in America is that of the Washoe Copper Company, at Anaconda, Montana. It is 300 feet high, and stands on a hill 427 feet above the works, four enormous flues leading from the furnaces to the stack proper. The real height is therefore 727 feet, while the inside diameter for the greater part of the stack is 31⅓ feet. The material is a cement-mortar capped with iron. The base is square, but the structure proper is annular.

Fleet of Ice-Yachts.

The ice-boat is a novelty to those who have never had the opportunity of coming in contact with these flyers over the frozen water. It has been demonstrated that they can actually travel faster than the wind that drives them when the breeze is at the proper angle, the reason being that the ice-boat forges ahead in a manner that enables it to catch new wind continuously. The making of a mile in thirty or forty seconds in one of these boats is not so unusual an occurrence, and the sport is not as dangerous as this speed suggests, owing to the fact that in case of a spill the boatmen simply slide along the ice. The illustration shows a fleet of modern ice-boats. It will be noted that the hull is simply a cross of stout timbers mounted on long skates or runners, and bearing a mast, the whole framework being strengthened with steel wires.

The development of mechanisms for fighting fire have resulted in many curious contrivances. One of these is the tall ladder shown

Courtesy Popular Mechanics.

A Fire-Ladder.

in the illustration, whose base is connected with a heavy truck, and which can be stretched out like a telescope to a remarkable height.

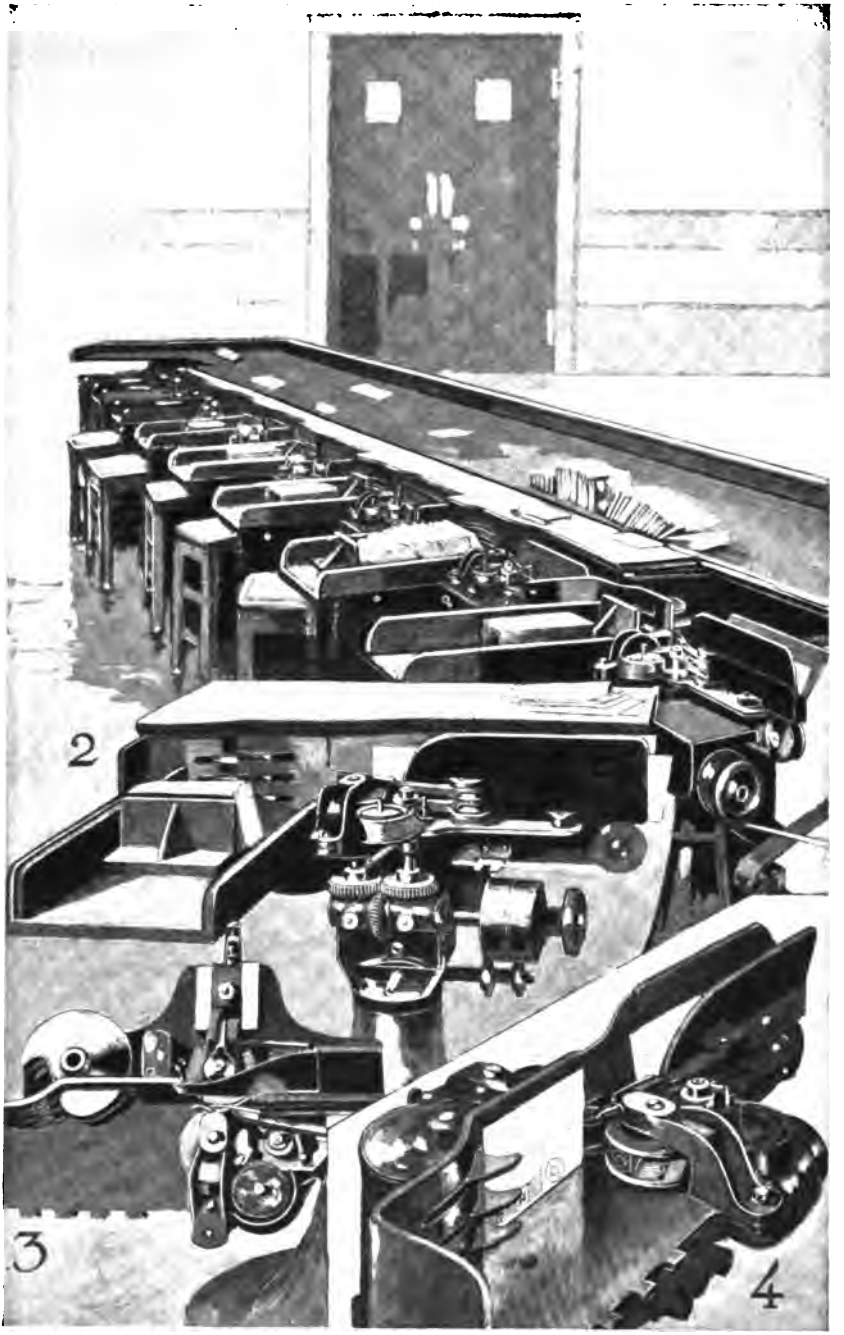
These ladders save many lives, enabling the firemen to reach comparatively high floors with great quickness. Life-saving mechanisms for coast service have also reached a high state of development. An equipment is illustrated on page 606.

The electric piano is not understood by many. It may be operated by a small storage battery or by connection with electric-light wires. A long cylinder is placed low down under the key-board of the piano, and a series of brake-shoes located close to the cylinder are so connected with the keys that when a shoe is lifted by contact with the cylinder the appropriate key is depressed. To play a given

A Comptometer.

piece of music there is used a prepared sheet of paper having holes representing the notes; this paper, in the form of a strip, is unrolled and moved along between points where electric connections can be made whenever a hole in the paper is presented. As the paper travels along the holes produce electric contacts, and when a contact affects a certain brake-shoe it is brought into position to be lifted by the cylinder. Thus the piano is made to render any piece of music for which the perforated paper strips are prepared.

The machines used for cancelling letters are most interesting. The illustration shows the Pikerdike machine, used in many large

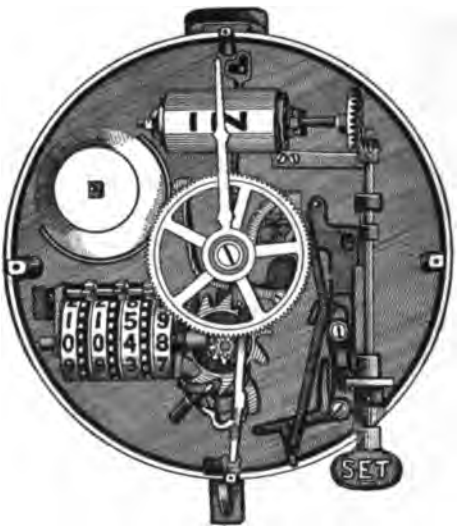


Pikerdike Letter-Cancelling Machine.

1, Series of machines actuated by one motor; 2, mechanism of the apparatus; 3, detail of the machine for cancelling and throwing out a letter; 4, passage of a letter under the cancelling-roller.

post-offices, both in America and abroad. The letters are fed into the slot at the right of the machine, and are carried between belts past the cancelling-wheel, after which the letter is thrown out. The protective devices are such that it is practically impossible for two letters to go through together. With this machine letters are cancelled at the rate of 175 or more a minute. The mechanism is well shown in the accompanying drawing.

Calculating machines are in extensive use. The Census Bureau employs a series of special machines devised for simplifying the work of calculating results from the returns received. Astronomical calculations are largely made on machines. For business purposes,



Mechanism of a Fare-Registering Machine.

such machines as the comptometer, made by Felt & Tarrant, are widely used. These perform the ordinary arithmetical calculations, and save a great deal of time in banking-houses and similar institutions.

The basic principles of most calculating-machines is similar to that of the fare-register, a view of whose interior is given here, because it shows the very simplest form of mechanical calculation—addition. Every time the conductor rings up a fare the right-hand figure-wheel turns one-tenth of its circumference, and when it has made an entire turn, it trips the next wheel, representing the tens, which registers a higher figure.

Until about fifteen years ago the builders of heavy machinery

in this country felt themselves in great need of suitable machinery for handling heavy weights The old-fashioned jib-cranes were generally used, principally because steam-power could readily be applied directly to them. Cranes of this type can, however, serve only a small floor-space, and, measured by that standard, were costly. Moreover, buildings containing jib-cranes of large capacity were necessarily strongly built to resist the heavy side strains brought upon them, and were correspondingly expensive. The overhead travelling cranes then in use were free from these objections, but possessed so many serious defects as to make them less popular. For indoor work it was impracticable to apply steam-power directly to them. Hydraulic cranes required the installation of expensive pumping-plants, accumulators, and motors. They were operated by means of numerous cables, running over a multiplicity of sheaves. They were slow and inefficient and never were largely used.

The mechanically driven cranes were of two types—one receiving power from a continuously running rope, the other driven by a square shaft. In both cases the power was subdivided and distributed by means of friction clutches. Changes of speed and of direction of movement were secured by the same means. It was necessary to use a very large number of gears. These cranes were costly. The expense of maintenance was large, while the speeds and efficiency were very slow. These defects prevented overhead travelling cranes from coming into general use for some years.

A well-known writer on mechanical subjects once stated that the multi-motor electric travelling crane, invented and developed by Mr. Shaw, was the most valuable contribution to the machine-building industry that had been made in many years, and that its introduction had revolutionized the business of building heavy machinery.

The Shaw Electric Crane Company, of Muskegon, Michigan, have made the development and improvement of the electric travelling crane and its adaptation to new lines of work their principal aim.

Their cranes are to be found in nearly every State in the Union, and in almost every civilized country on the globe. English, French, German, and Russian builders have patterned after the Shaw cranes.

The accompanying illustration shows two single trolley cranes in the new locomotive repair shop of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad at Columbus, Ohio. The capacity of the main hoist is seventy-five tons. Each trolley carries two auxiliary hoists of ten tons' capacity. The span of the cranes is

Courtesy Manning, Maxwell & Moore.

Shaw Electric Crane, Lifting 150-Ton Locomotive.

seventy-six feet four inches. They are driven by direct current at 250 volts. These cranes fairly represent the standard type of heavy electric cranes. The girders are of the double web or box section type. There are four wheels under each end of the crane. The motors are slow speed, have large shafts and commutators, and machine-formed coils. The controllers are fire-proof, mica being the only insulating material used that is exposed to heat. They are all constructed so that thorough ventilation and large heat-radiating capacity are secured.

MINOR MISCELLANEOUS INDUSTRIES

Lead-Pencil Manufacture

The ordinary lead-pencil is a core of graphite and clay enclosed in a wooden case. Graphite is a substance familiarly known in a common form of stove-blacking, and also sold in sticks as a lubricant for bicycle chains. The wood used is principally cedar, and requires to be straight-grained, comparatively soft, and capable

Courtesy Scientific American.

View in Lead-Pencil Factory.

of taking a polish. The best wood for the purpose is grown in Florida and Alabama, the well-known Faber pencils being manufactured at Cedar Keys, Florida, where the desired wood is found in abundance. In manufacture the wood is first cut into slats a quarter of an inch thick and two and a half by seven in the other dimensions. These slats are thoroughly dried, after which they are passed through a grooving-machine that cuts a row of grooves in one face. The leads being laid into these grooves, a similar grooved slat is surfaced with glue and laid on top, so that the two slats unite and require only to be cut up to form a series of lead-pencils.

This cutting is done in a moulding-machine, which delivers

the pencils either round or hexagon, according as it is set. The pencils next go to sand-papering machines, where they are smoothed, after which they are stained or colored by a machine that feeds them through small apertures, where they receive a thin coat of varnish in passing. On coming out of this machine they are carried slowly on a long belt in order to give them time to dry. To produce a finely-finished and highly-polished pencil it is necessary to pass them through this varnishing-machine several times, thus securing an enamel effect. The highest-priced pencils are hand-polished, a work that requires considerable experience.

The stamping of the pencil is done in a press, gold-leaf being used for the best pencils. In this work the steel die is heated and the gold-leaf cut into narrow strips, which are fed into the press as the stamp is applied. The heat of the die causes the gold-leaf to adhere to the pencil, the surplus leaf being brushed off to be remade into gold-leaf.

The graphite used to form the leads is mined in Mexico, Eastern Siberia, Bohemia, and Ceylon. It requires to be broken up and ground, and mixed with clay in order to make a hard pencil; the more clay used the harder is the pencil. The hardness is somewhat dependent, also, upon the compressing of the lead in forming it into strips for use in the pencil. This is done by forcing the plastic mixture of graphite and clay through holes formed in hard mineral dies under a heavy hydraulic pressure. The dies are mostly cut from sapphires or emeralds, and the lead comes through looking very much like a wire, and is cut into the proper lengths.

The rubber used in the heads of pencils is sometimes glued into a hollow in the end, and sometimes attached by means of a small metal ferrule.

Carpet Manufacture

In 1800 most of the carpets made in the United States were woven with rags on the old-fashioned hand-loom. The manufacture of Axminster carpets was begun in Philadelphia as early as 1791 by W. P. Sprague, and carpet-making has been one of the more important industries of that city ever since. The Sprague carpet factory is especially noteworthy as being the first American industry to be protected by a tariff, Congress passing in that year an act placing a duty of two and a half per cent. upon imported carpets, it being stipulated that the money was to be used to encourage wool-growing.

Carpets are woven much as cloth, except that a pattern is always required, and usually a pile or raised portion of the fabric. To understand the method of interweaving the strands, the reader is referred to the chapter titled "Progress in Textile Manufactures," where is explained the principle of the shuttle operating to form the web. The Jacquard pattern-card attachment serves to vary the position of the threads, thus producing a pattern.

The pile of a carpet is formed by looping the strands over a wire, and if the loops are left in, it is called uncut pile, or, if cut, it is cut pile, the latter giving a surface to the carpet full of exposed ends of a soft and velvety appearance.

The manufacture of ingrain carpets was begun early in the nineteenth century in Frederick County, Maryland, hand-looms being used. A small factory was also started in Medway, Massachusetts, in 1825, by Alexander Wright, who brought hand-looms from Scotland for the purpose. This was the basis of the Lowell industry, the mill soon passing into the hands of the Lowell Manufacturing Company.

By 1844 carpet manufactories were established at six other places in the United States, and it was in this year that Erastus B. Bigelow, of Boston, adapted the power-loom to the weaving of ingrain carpets, becoming a conspicuous figure in the carpet world, so much so that it is claimed for him that he did more than any other one man to develop the carpet industry of the world. About 1850 he patented the power-loom with Jacquard attachment for weaving Brussels and Wilton carpets. Later he developed the weaving of tapestry Brussels and tapestry velvet; in fact, he was more or less responsible for a majority of the important improvements in carpet-weaving machinery during his time. He established the Bigelow Carpet Company, and sold his loom for making Brussels and Wilton carpets to English manufacturers for a large sum.

An important improvement in power-looms for making Axminsters and Moquettes was introduced in 1867 by Alexander Smith and Halcyon Skinner, of Yonkers, New York. This machine increased the product to eleven yards a day, and was controlled for many years by the A. Smith & Sons Carpet Company, which developed an enormous business. Other pioneer inventors of carpet machinery were Duckworth, Murkland, and Crompton.

About 1885 the power-loom was adapted to the manufacture of Smyrna carpets and rugs, which resulted in a largely increased output.

In 1900 there were 133 carpet factories in the United States, having a total capital of nearly $45,000,000, and giving employment to nearly 15,000 persons; the number of looms in use was 12,511, and the annual value of products over $48,000,000. The industry is nearly ten times as great as it was in 1850, and is double what it was in 1875, but during the last ten years its growth has been very moderate. There has been a tendency towards combination, the number of firms engaged in the industry having steadily decreased since 1870.

Perhaps the greatest drawback to the manufacture of carpets in the United States is the fact that nearly all the wool is imported, the domestic wool, which constituted four per cent. of the quantity used in 1890, having fallen off to the insignificant figure of one-fifth of one per cent. in 1900. Very little cotton is used, but nearly one-half of the material employed is linen, jute and other yarns.

By far the largest quantity of carpet manufactured in 1900 was two-ply ingrain, of which there were 37,000,000 yards produced; the tapestry and Brussels amounted to 12,000,000 running yards, the tapestry velvet to nearly 6,000,000 running yards, while the Axminster, Wilton, and body Brussels come next in order. In addition to the carpets named, 9,000,000 square yards of rugs were manufactured, this portion of the industry showing very marked gains in the past dozen years. Smyrna rugs are the favorites, being the lowest in price after ingrain. The census figures also show that Wiltons, Axminsters, and Moquettes have increased in use at the expense of tapestry Brussels.

The centres of the carpet industry of the United States are in Pennsylvania, New York, Massachusetts and New Jersey, about three-eighths of the total capital being invested in Philadelphia and its suburbs.

Laundry Machinery

The modern laundry involves the use of considerable up-to-date machinery. No old-fashioned wash-boiler, wash-board, or ironing-board has a place in such an establishment. The washing is done in washing-machines, of which there are a great variety, the most popular form having two cylinders, one inside the other. The clothes are put into the inner cylinder (which is perforated) together with powdered soap, and too often some strong dirt-destroying chemical, and closed in, after which steam, or hot water and steam, are admitted to the outer cylinder. The inner cylinder is then turned first in one direction and then in the other, so that the clothes receive

a thorough shaking, twisting and rinsing. After a time the water is run off, the dirty water being forced out by centrifugal force. A second application of hot water and then of cold water (which latter contains the bluing) completes the washing process.

For drying the clothes the centrifugal wringer is commonly employed. The clothes are placed in great baskets of tinned copper and rotated at a speed of perhaps eight to eighteen times a second. By this means the moisture is literally thrown out, and the clothes are almost completely dried in a few minutes. After being thus dried, the clothes are found to be very tightly packed against the sides of the basket of the machine, and mechanism is usually applied

Placing Clothing in the Washer.

to loosen them slowly, so that they can be taken out easily without danger of being torn.

Steam-drying closets are used for such clothes as it is desired to render quite dry, these being treated with steam-coils and containing numerous compartments for the clothes. The temperature is kept so high in some of these drying-rooms that the employees cannot endure it, hence mechanism has been devised by which the clothes can be passed in and taken out from the outside of the room.

Several forms of machines are made for starching, that used for collars and cuffs having a wheel which dips the article clear down into the starch, holding it under for a short time. For larger

articles there are special machines that work the starch thoroughly into the material.

For dampening articles before ironing a variety of machines are in use, being differently designed for the different articles, as one for shirts, another for collars and cuffs, etc. In these the clothes are subjected to a slight sprinkling, after which they are ready for the ironer. The most common form of collar-and-cuff ironer has a cloth-covered cylinder, which is heated and rolled back and forth over a table that is likewise heated, the ironing being accomplished by laying the collars and cuffs flat on the table and allowing the roller to pass over them. There is one of these machines in Troy,

The Drying Closets of a Modern Laundry.

New York, which has a capacity of about 15,000 pieces a day. Another common form of ironer passes the goods between pairs of rollers. Turn-over collars require a special machine, and there are likewise special machines for yokes, sleeves and wrist-bands.

Paints and Varnishes

The manufacture of linseed oil was begun in New York in 1715, and three years later a small factory was established in Connecticut. In these and other early factories wind- or water-power was commonly used for crushing the flaxseed, and as late as 1790 an old windmill stood about a quarter of a mile north of the present New York City Hall, grinding flaxseed for the making of oil for the house-painters of that period. Before 1800 the use of paint

was regarded as a luxury; in fact, the early Puritans regarded it as a sin to apply paint to their dwellings, this being in their estimation an ungodly proceeding. But by the beginning of the nineteenth century it became a matter of common knowledge that paint served to preserve wood and that its use was therefore a real economy.

The manufacture of white-lead paint was begun in Philadelphia in 1804 by Samuel Wetherill. He succeeded in making as good white and red lead as had been previously imported, and established a considerable trade. The making of colors for use with lead paints was begun by Anthony Tiemann in 1806 or 1807, in Philadelphia, and by 1811 he was manufacturing twenty-two distinct colors. At the same date there were started three red-lead factories in Pittsburg. Not long after chromic iron was discovered in Chester County, Pennsylvania, and this gave great impetus to the grinding of paint.

The first manufacturer of varnish of whom there is any record in this country was P. D. Smith who had a place on the Bowery in New York in 1828. He was not very successful, but the concern of Tilden & Hurlburt, which started in 1830, did a large business for many years, importing gum copal from Africa, and manufacturing the varnish in New York, and establishing sales not only in the United States, but to a considerable extent in South America.

About 1850 deposits of zinc were uncovered and worked in New Jersey, the zinc oxide being secured in the form of a white powder, which was found to be an excellent substitute for white lead, and came into extensive use in mixing paints. During recent years another substitute for white lead has been manufactured from fluorspar.

The manufacture of ready-mixed paints was wholly an American idea, and began in 1852, coming rapidly into public favor, having now been established for many years as most satisfactory for house paints.

The principle by which paint serves to protect wood or other porous material from decay or other injury consequent to exposure to the weather is twofold. The oil is more or less absorbed, tending to prevent the entrance of moisture into the pores of the wood. The lead or other mineral in solution in the oil as it dries also forms a thin metallic covering that keeps out the air, and so prevents rust or oxidation, where used to protect ferric structures.

In 1873 there was organized the first of a series of paint, oil, and varnish clubs, which shortly became established in all the larger

cities of the United States. These clubs take cognizance of matters of general interest in the trade, and have been of material value in many ways. During recent years there has been a tendency to concentration of interests, and the National Lead Company was formed with a capital of $30,000,000, this concern controlling the greatest portion of the output of white lead, while the National Linseed-Oil Company, capitalized at $18,000,000, controls the bulk of that branch of the trade.

The Wall-Paper Industry

The manufacture of wall paper began in the United States in 1790, when the Howell factory was established at Albany. This was later removed to New York and then Baltimore, and in 1820 located in Philadelphia, where it occupies a leading position in the industry. The first wall-paper printing-machine used in this country was imported by the Howells in 1844 from England, this being a one-color machine. It was followed by a six-color machine in 1846, and some years later the Waldron factory in New Brunswick began the manufacture of wall-paper machinery for American firms.

There are now about forty factories in the United States, manufacturing about $15,000,000 worth of wall paper annually, which goes to enrich the interior walls of dwellings. The trade demands a new line of designs every year, and the production of these entails a large part of the expense of conducting the business.

The printing-machine employed since 1870 operates on what is known as the continuous system. The paper in the form of a roll first passes through a grounding-machine, that imparts the body tint to its surface. It then goes to a hot-box or drying apparatus, continuing to the color-printing machine, where it passes over a large cylinder set centrally between a series of small cylinders, each of the smaller cylinders printing a portion of the design in its own color. Since 1882 it has been found practical to print bronze colors on wall paper, the liquid bronzes being mixed with potato starch, which does not impair the lustre, as did every adhesive material previously tried. In this manner are produced the many beautiful designs which vie with the art of the lithographer and other color printers.

The common-sized roll of wall paper is twenty-four feet long and twenty-two inches wide, but hand-printed paper is made thirty inches wide. There are twelve rolls in a "piece," twenty-four rolls

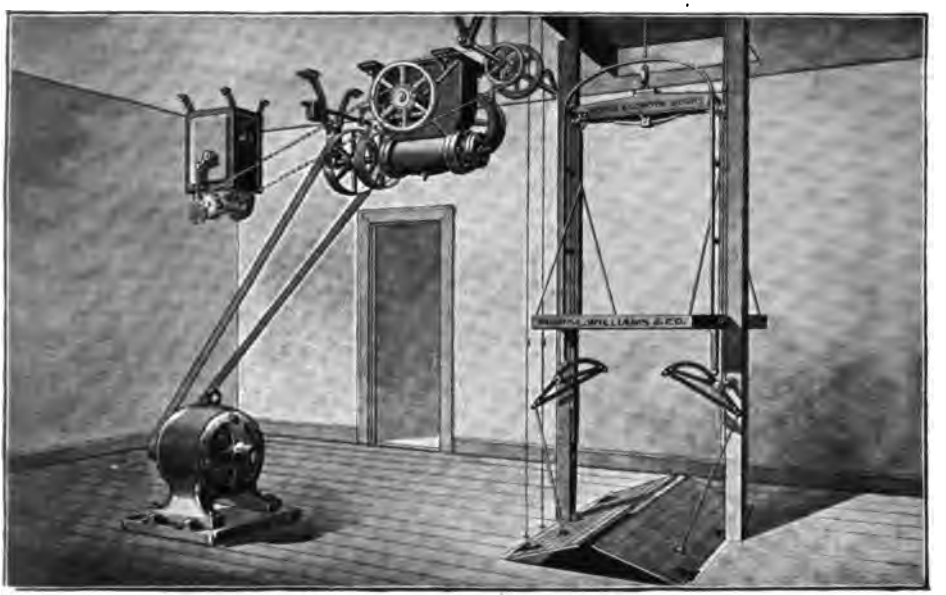
in a "lot," and fifty rolls in a "bundle." The designs for machine-made wall paper are produced on cylinders, but for hand-printing the designs are engraved on flat blocks of maple wood. These blocks are built up of four layers, in order to prevent warping or distortion of form in the block. The hand-printed paper is the most ornamental, and sometimes includes sixteen or eighteen colors and printings, and of course a block has to be engraved for each color. In hand-printing the printer operates on a roll of paper, his printing-block being suspended above by springs. Small dots on the margin of the paper guide him in bringing the block to the proper point; and after he has impressed the design on and formed a complete pattern, he repeats it on the next section of the roll, making the joints with marvellous accuracy. The hand-printed papers run a great deal to ornamentation with colored flock and gold bronze. This flock is waste from the silk-mill—beautifully colored little bits of silk chopped up fine, and made to adhere to the design printed in a varnishy ink, giving a raised velvety effect that is much admired, and which cannot be successfully imitated by any machine-printing.

Elevators

The increasing number of tall steel buildings has called for considerable improvements in the construction and arrangement of elevators. These are now made to travel at express speeds, and also to carry extremely heavy loads, while the liability to accident is very slight. The chief protection against the danger of a long fall has been obtained by the placing of an air-pocket at the foot of the elevator-shaft. This air-pocket is nothing but a strong, steel, air-tight box, open at the top, with a space just large enough to admit the elevator. Should the elevator fall into the pocket it is cushioned by the air, whose elasticity produces the most perfect spring known to mechanics. An experiment made at the Empire Building, corner of Broadway and Rector Streets, New York, a few years since, proved how perfect a safeguard is a large air-pocket. One of the elevators, weighing two thousand pounds, was dropped from the twentieth story to note the effect. A number of eggs and incandescent-light bulbs were placed on the floor of the elevator, and not one of them was broken by the shock, the elevator bounding on the air in the "springiest" fashion. This experiment was outdone at the Philadelphia City Hall later, where the tower elevator, weighing 2400 pounds, was dropped 400 feet into the thirty-five foot air-

pocket to note the result. In addition to electric-light bulbs and eggs, six rats were given a free ride. All landed safely.

Three types of elevators are in common use, known as the drum, hydraulic and screw. The drum is the commonest, this having a large drum that coils and uncoils the supporting wire-rope. Electric motors are commonly used to furnish the power, being connected with the drums by worm-gearing. The hydraulic elevator operates with a piston working in a long cylinder, the water being pumped from one end of the cylinder to the other, thus moving the piston that controls the rope mechanism. Though an ideal system,



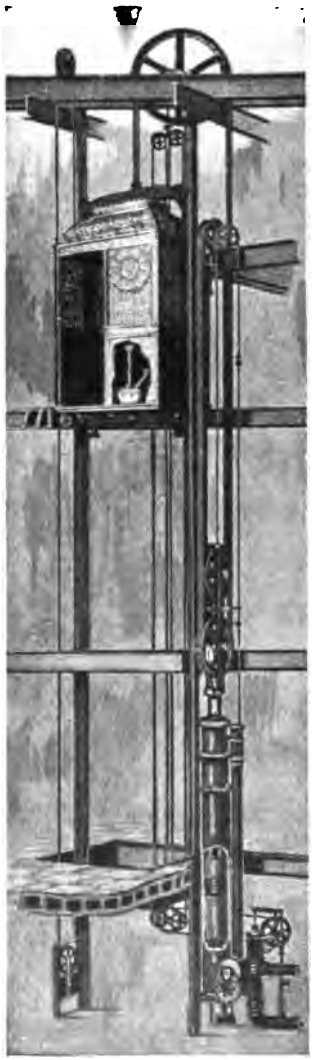
Mechanism of a Freight Elevator.

it is not suited to great heights, because this requires too long a cylinder, and in ordinary practice it is used mostly for sidewalk elevators.

The screw-mechanism as now made is very ingenious, a long, heavy, horizontal screw being fitted with ball-bearings on the threads, the balls bearing against and pushing along a large sheave or nut, that is moved sideways and geared to the elevator ropes, usually in the ratio of one to eight.

Freight elevators are commonly manufactured as shown in the illustration, to drive with an ordinary electric motor and belt power; they are protected against falling by a system of catches,

which is set in operation by the releasing of a powerful spring if the supporting rope breaks.



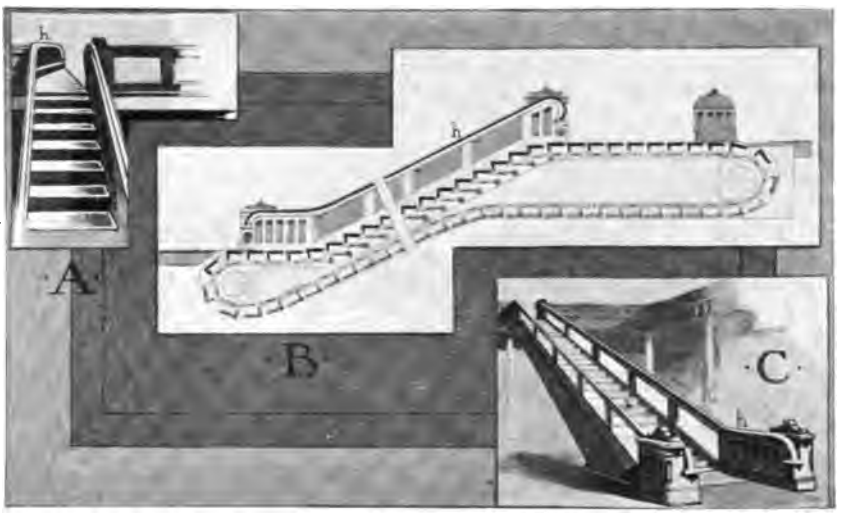
Courtesy Morse, Williams Company.

A Vertical Cylinder Hydraulic Elevator.

Controllers or speed governors are used in operating elevators, being usually fitted with a wheel or a lever for the use of the elevator-man. The best of these are so made that should the car attain an

undue speed in descending they act directly on the safety device to bring the car to a stop.

The " boyless" elevator is the latest thing for apartment-houses, hotels, etc. It operates by push-buttons. If a man on the fourth floor wants to go to the eighth, he simply pushes the button and waits. The elevator comes to his floor, stops, and the door opens automatically. He steps in, and pushes elevator-button No. 8, and the elevator takes him there and stops again, opening the door. If some one on floor No. 6 has pushed his button just after the fourth-floor man got on, the elevator will stop and take him in on the way. This elevator does everything an elevator-boy can do except take tips or " sass" the passengers.



The Escalator.

A, Top of Escalator, showing the shear that intimates to the passenger, " Time to get off;" B, engineer's plan, showing mechanical operation; C, front view, showing moving stairs and the hand-rail; h, h, h, h, rubber hand-rail, moving in unison with the stairs.

The escalator, or travelling stairway, is a new form of elevator. As constructed for the " L" road in New York City, the steps are made to operate as links of an endless chain, and a person may walk up the stairs in the ordinary way or be carried upward by the travel of the steps. The best form is that shown in the illustration, which is used at Twenty-third Street and Sixth Avenue, New York. These moving stairs are so satisfactory that they are being adopted by many large department stores.

Telpherage and Aerial Transportation.

An elevated wire rope or rail as a trackway for transportation is an old device familiar to mechanics, but not so well known to the general public, because such constructions are most frequently erected in out-of-the-way places, where none penetrate but those whose work or business interests require it. In mining regions, where a mine is opened, say on a hillside, in a new country devoid of roads, the use

Courtesy United Telpherage Company.

Telpherage System at a Gas-Works.

of a wire ropeway, to which a car or other carrying device can be attached, is quite common for transporting things down hill by gravity, and up hill by some light power, or perhaps by the pull of heavier loads coming down. The word telpherage is more usually employed to designate aerial railways operated electrically, especially those in which there are cars operated by independent electric motors, and running along a stout wire or rail supported by a superstructure. Two of these are illustrated herewith, furnishing a very cheap and easy means of conveying goods from a factory to be loaded on cars, or from one portion of a manufacturing plant to another.

For handling coal, automatic railways are largely utilized, the coal being transported entirely without hand labor. Hoisting machines take the coal direct from a vessel's hold to the cars of a light

elevated railway, and these are run along (often by gravity) and dumped at any desired point on the route, either into storage bins or into coal-cars for a further journey.

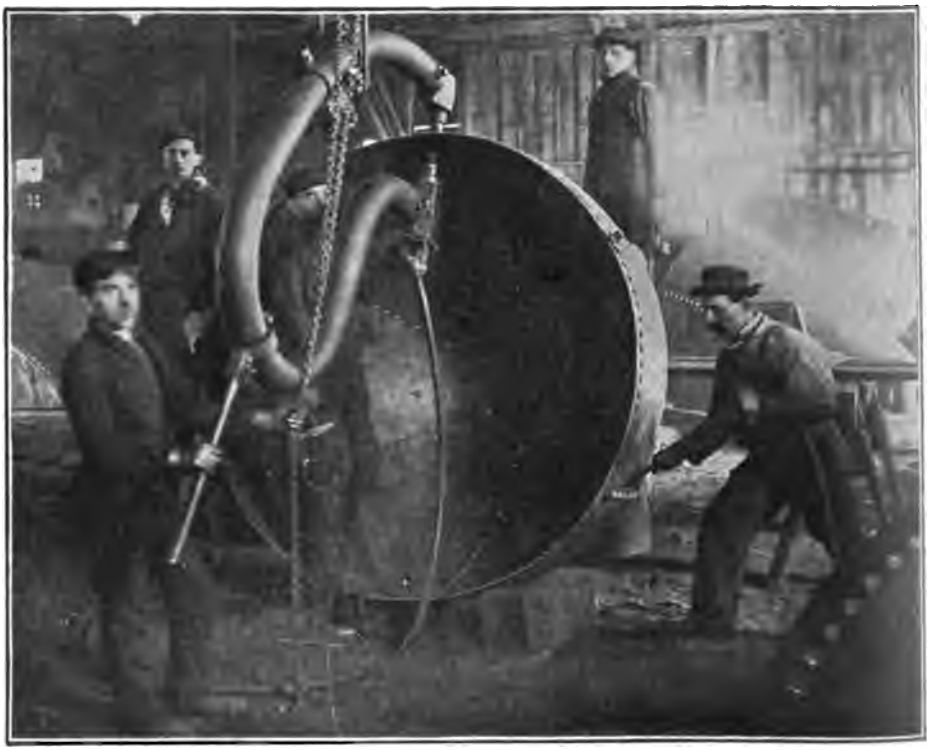
Courtesy United Telpherage Company.

Telpherage System, showing Carriers and Hoist.

Compressed Air and Refrigeration.

The air-compressor is a very useful machine that resembles a steam-engine in appearance—in fact, usually includes a steam-engine as a part of its mechanism. The steam-engine furnishes the power to compress air in a cylinder very much like the steam-cylinder, but operated on a reverse principle. At every stroke a cylinderful of air is compressed and driven out through a pipe to a storage reservoir of some sort. The air-compressor shown in the illustration is of the direct-acting steam type, and may be used among other purposes for a refrigerating system. The working principle of many ice-machines is based on the creation of heat during the compression of the air, in accordance with the well-known law that pressure creates heat. When this compressed air becomes thus heated, and is robbed of its heat either by a surrounding coil of pipe in which flows cold water or by giving it sufficient time to cool off, then the air may be again expanded to produce cold. (See page 473.)

The expander also resembles a steam-engine, a common form being like the usual horizontal cut-off engine, into the cylinder of which the air is admitted during a portion of the stroke of the piston; the admission being then cut off, the air expands during the remainder of the piston's stroke, until it fills the entire cylinder. During this expansion the air is cooled to a low temperature, and then pushed out (by the return stroke of the piston) into pipes that convey it to the refrigerating-room or other place to be cooled.



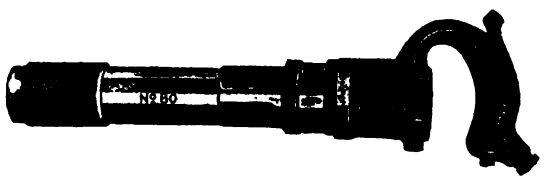
Courtesy Philadelphia Pneumatic Tool Company.

Yoke Riveter Making a Government Buoy.

In the Allen dense-air ice-machine the air is used at a pressure of five atmospheres, being circulated and used over and over again. This is found to give very good results, as there is less moisture to deal with, always an annoyance in these machines, and the size of machine for a given result is reduced. Ice-machines of this type are frequently employed on ocean yachts and steamers, being located in the engine-room, where they can be attended by the regular engineers, while they drive the cold air they make to

the refrigerating-room at some other point on the vessel, and thus secure for the voyagers all the comforts of fresh provisions that they could enjoy on land.

In ice-making plants in large cities or elsewhere the ammonia system is commonly employed, because ammonia has a very convenient boiling-point, and it can be changed from gas to liquid and back again at small expense. The ammonia is used on the same principle as the air—compressed, then cooled, then expanded, and the expansion used for refrigerating. In compression the ammonia becomes liquid, and under expansion it is gaseous, which changes are of advantage in the work to be performed. The Frick Eclipse ice-making machine shown on page 335 is a familiar type, embodying a compressor-pump and steam-engine, and in the larger sizes has a height of eighteen feet and a capacity of 150 tons of ice in twenty-four hours.



A Pneumatic Hammer.

Compressed air is employed as a source of power in many tools and machines, being supplied much as is electricity, a pipe being substituted for a wire. The pneumatic hammer illustrated is one of many convenient small tools that are replacing the older and more familiar forms. The workman simply holds the pneumatic hammer up to its place and the compressed air produces rapid blows of the hammer, furnishing all the power, and thus accomplishing very much more work in a given time than a man could accomplish with a hand hammer. Riveting is now very commonly done with pneumatic tools, and the picture of a government buoy being riveted together by a portable compressed-air riveter is only one of many that might be shown of the methods now common in all large shops that manufacture constructions of sheet metal.

Compressed air is in some sense a rival of electricity, having come into use about the same time, and providing a power that has much the same elasticity of use. It has hardly been a success for driving street cars, but it is useful in mining and underground haulage, there being hundreds of compressed-air mining locomotives in use. For rock-drilling, for operating brakes and signals, for some sorts of pumping, for propelling packages through tubes, and

numerous special uses compressed air has proven most serviceable, and holds its own against devices operated mechanically or by electrical means.

Wire-Making

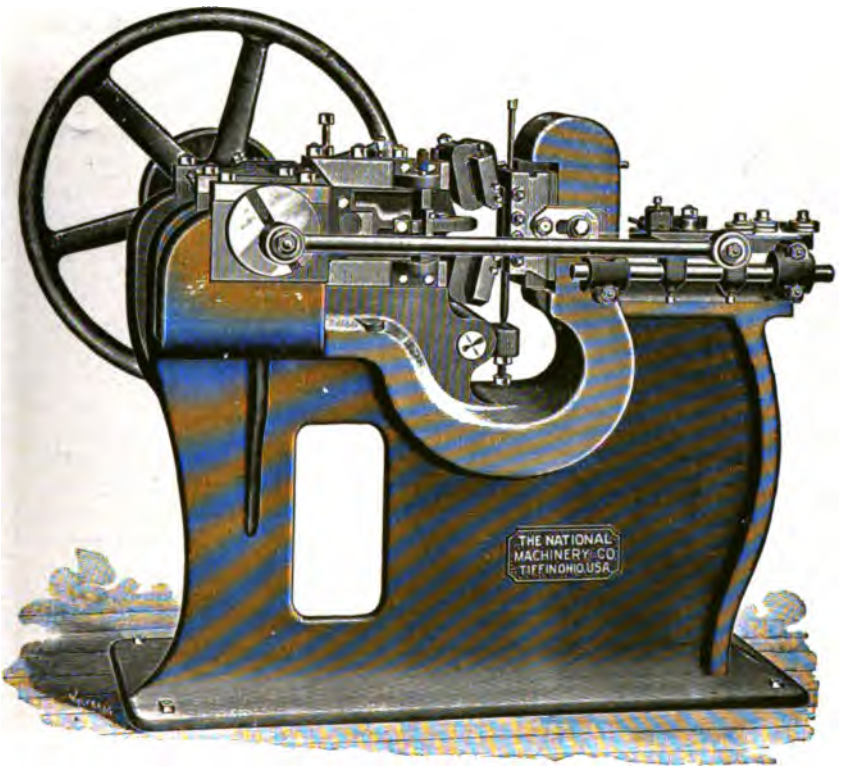
Wire-drawing is the process of drawing a metal rod through a series of holes of constantly reducing diameter, until the desired size and section are obtained. Down to three-sixteenths inch diameter strips of metal are termed rods, bars or the like, being produced

Wire-Drawing Mechanism of the Morgan Construction Company.

by rolling in the rolling-mill. Wire has been drawn as fine as the one-seven-thousandth of an inch in diameter, this size being microscopic. The holes through which the metal is drawn to reduce it are formed of steel dies of extreme hardness, or for great accuracy and especial fineness diamond dies may be used.

The view in a wire-drawing establishment on this page affords some idea of the work. The handling of wire in great lengths requires much room and many ingenious contrivances. The average man thinks of wire as being round in cross-section, but it is made in

a great variety of sections for special purpose. The pinions of watches, for instance, are cut off from pinion-wire that is grooved all around to form the cogs or teeth of the pinions. Wire for typewriter bars may be rectangular or of other special form. For wiring commutators the wire is given a cross-section resembling the keystone of an arch, this being to fit the curve of the commutator to which it is to be applied. Grooved wire is made for eye-glasses, which, being bent around, holds the lens or glass in position.



A Wire-Nail Machine.

Machines for forming or cutting wire into loops, bends, or special forms, as for staples, hooks, eyelets, etc., are termed wire-forming machines. They are made in great variety, according to the work required of them. Wire-stitchers, employing fine wire for stitching or binding pamphlets or periodicals and sometimes cheap books, have been used by bookbinders for many years, and have been one of the things tending to reduce the price of weekly and monthly publications.

Nails, which were formerly nearly all cut from thin sheets of iron plate, are now almost wholly made from wire. A strip of wire is run through a special machine and finished nails are delivered. The accompanying cut shows a familiar type of wire-nail machine, manufactured by the National Machinery Company. The wire is fed into the machine from the coil, and one complete nail is headed, pointed, and cut off at each revolution of the fly-wheel. The incoming wire passes through straightener rolls to insure straight nails, and the size of the head to be produced can be regulated, as can also the length of the nail. The output of the machine is from 125 to 500 nails a minute, depending upon the size.

INDEX

A

Accidents on railways, 253
Acetylene gas, 260–264
  generators, 262, 263, 266
Acids, production of, 593
Acoustiphone, 408
Ader, M. Clement, 113
Adulteration of foods, 337
Aeronautics, 91–117
Aeroplanes, 94–103
Aerostat, Wright brothers', 98–101
Agricultural Department, United States, 214
Agriculture, 208–222
Air-compressor, 631, 632
  ships, 91–117
Alcohol motor, 134
  production, 543, 545
Aluminum, 570–572
  plate-printing, 369
Ammonia, 593
  absorption system, 334, 335
  in ice-making, 633
  motors, 476
Amusement machinery, 426–440
Annealing coin, 441
  furnace, 443
  lehr, 499
Anthracite coal, 320, 321
Appert, Nicholas, 326
Architecture, modern, 502–516
Arc light, 258
Armor-plate, 190, 331
  plate-press, 86
Armour & Company, 331
Arrow, steam-yacht, 161
Artesian pump, 339
Artistic bridges, 425, 426
Ash-carting, 597, 598
Asphalt roads, 146
Associated Press of New York, 378
Assuit dam, 349
Astronomical instruments, 400, 401
Atlantic's liners, 164
Automatic block signals, 233
Automatons, 426, 427
Automobiles, 118–134
Auto-mower, 221
  -truck, 133
  -van, 131
Autoplate machine, 380, 381
Aviator, Roze's, 108
Axminster, 619

B

Bagdad railway, 239
Baking machinery, 334
Baldwin, John, 583
  locomotive works, 230
Ballasting a railway, 232, 240
Balloons, 92, 103–109
Baltic, 169
Bardon alcohol auto, 134
Barkometer, 531
Barnard, Professor, 24
Battery, 44, 129, 609
Battle-ship, 150–157
Beef-packing industry, 330–332
Beer manufacture, 547, 548
Beet-sugar, 573, 576, 577, 578
Behr railway system, 226
Behring Strait railway, 234.
Bell, Professor Graham, 103, 116
Berliner, E., 113, 407
Berlin-Zossen experiments, 225
Bessemer converter, 85
"Best Friend" locomotive, 230
Bicycle, 113
Bigelow, Erastus B., 620
Biltmore estate, 282
Bituminous coal, 320, 325
Blast-furnaces, 67, 76, 77
Blasting, 294, 585, 586
Bleaching-machine, 528
Block systems, 245, 251
Blood, uses of, 592

Blooming-mill, 77
Blooms, 68
Bolt-cutter, 452
-making machine, 451, 452
Bookcase-machine, 370, 372
Book-sewing machine, 372
Boots and shoes, 534
Boré, Etienne, 573
Boring-mill, 459
Bottle-blowing, 497, 499
Bottling industry, 549.
Boynton railway, 228
Bran-duster, 523
Breakers, 324
"Break-throughs," 325
Breech mechanism, 188
Brewery mash, 593
Brewing industry, 547
Brick-conveyor, 570
-making, 566, 568
Bridges, 412–425
Bridge-trusses, 412
-towers, 417
British coal-mines, 321
Broaching slate, 583
Brooklyn bridge, 416, 418
bridge trains, 243
Brott railway system, 228
Brown conveyor, 72
Brussels carpet, 620
Building industry, 502–516
Buoys, 24, 632
Bureau of Soils, 214
Butter-making, 333
By-products, 588–593

C

Cableway, 201
Calcium carbide, 263
Calculating machine, 614
Calendering machine, 539, 540
paper, 390, 396
California gold, 300, 301
"Camera fiend," 381
Campania, 166
Canal lock, 173, 196, 198
Canals, 194–200
Canneries, 326
Canning statistics, 328
-tools, 328
Cantilever bridges, 419
Canton-Samshuy Railroad, 236
Caoutchouc, 538
Cape railway, 239
Capitol at Washington, 504, 505, 507
Capping tables, 328
Car, convertible, 234
Carburetter, 266
Carnegie steel works, 70
Carpet manufacture, 618–621
Carpets, pile weaving, 490, 617
Carré ice-machine, 334
Carriage building, 123
Casing-in machine, 372
Casting-pit, 66
Cathedral glass, 500
Cedric, 166
Cellulose, 155
Cement, Portland, 508, 515, 516
Centrifugal machine, 576
Cereals, 334
Cervenka, Emanuel, 407
Chalk, process of illustrating, 381
Channelling machine, 586
Chanute, Octave, 91
Cheese factory, 333
production, 332
Chess-player, automaton, 427–429
Chicago drainage canal, 198, 200
tunnel sewer, 207
Chlorination process, 297, 298
Chromos, 369
Cigarette business, 554
Circle of death, 435
Class journalism, 384
Clay modelling, 604
productions, 566–572
Clothes-drying apparatus, 622
Clothing, promotive, 483
Coal-cutting machine, 324
-field surveying, 325
-gas, 264, 267.
-jigs, 325
-mining, 320–325
Coaling at sea, 157
Cog-railway, 245
Coherer, 54–56
Coke, 593
Cold storage, 334
Collins's wireless telephone, 61, 62
Collodion, 358

Color printing, 369, 370, 379
Combing-machine, 392
Composing-machine, 364–369, 385
Compound engine, 463
Compressed-air locomotive, 247
-air motors, 473, 475
refrigeration, 336, 631–634
Comstock lode, 303, 305, 306
Concrete building construction, 507
Condensed milk, 332
Continuous-tank furnace, 496
Converter, electric, 36, 273
Conveyors, 71
Copper deposits, largest, 310
industry, 46
Corn-cutting machines, 328
-silking machines, 528
Cotton-baling, 490, 491
industry, 484, 485, 486, 488
manufacturing, 483–494
waste, 591
Country newspapers, 384
Covent Garden Opera House, 435
Cracker-making, 334
Cranes, 81, 458
Crank-shaft, 168
Cream separator, 333
Creameries, 333
Cremation of garbage, 595
Croton dam, 344
water supply, 342, 344
Crude oil, 558, 564, 565
Cruisers, 158
Cultivators, 220
Cupelling apparatus, 445
Curious industries, 602–617
Cut glass, 500, 501
Cutting logs, 279
Cyanide process, 297
Cylinder-presses, 361–364, 377

D

Daggert, Ezra, 326
Daily newspapers, 382
Daimler, Gottlieb, 124
Dairy statistics, 332
Dams on the Nile, 349, 350
Davidson, G. L. O., 116
De Beer's diamond mine, 316–319
"Degras," 591
De Laval, 468
De la Vaux, 105
Dellwick and Fleischer process, the, 264
Derricks, steel, 556
Deutschland, 166
Dexter feeding-machines, 374
Diamond-sorter, 319
Diamonds, cost of mining, 319
largest, 314
Differential reel, 523
Dipper-dredges, 352
Dirigible balloons, 103
Disappearing gun, 185
Distilled liquor, 545
Distilleries, 545
Dobby, 490
Dough-mixer, 334
Drainage canal, 601
Drawbridges, 421
Dredges, 350
Dredging for gold, 300, 301
Drilling-machines, 451
oil-wells, 556–558
Drinking-water, 538–544
Droz, Jacquet, 426
Drydock, 163
Drying closets, 622
Dumont, Santos, 91, 92, 105, 106
Dykes, Holland, 346, 347
Dynamos, 18, 39, 40, 43

E

East Indian railways, 39
Eddy kites, 94–101
Éden Musée, New York, 427
Edison magnetic concentrator, 74
Thomas A., 406, 409, 410
Edwards, Colonel William, 528
Electric and steam trains, 243
-cab service, 129
cars, 230
converter, 35
elevated railway, 241
heating, 30–32
light, 254–258
stations, 255, 257
locomotives, 224, 247
motors, 44, 476, 477
piano, 612

Electric railway, 225
runabout, 130
signs, 28
steel-cutting, 32
towing system, 37
track-welding, 32
Electrical anæsthesia, 29
machinery, 18
Electricity direct from coal, 608, 609
for farm use, 21
Electromagnet, 34
Elevated railways, 241
Elevators, 626–629
grain, 524, 525
portable, 508
Empire State Express, 228
Engineering enterprises, 346, 352
Engine-room, 23
Engines, 461–480
Escalator, 629
Etheric waves, 52
Ether-motor, 134, 135, 476
European newspapers, 384
Express trains, 233

F

Factory chimney, Germany, 609, 610
wastes, 588–593
Faraday, 17
Fare-register, 614
Farming implements, 219, 220
Farnham, E. W., 242
Fatalities on railways, 252
Feeding-machines, paper, 375
Fermented liquors, 543
Ferracute manufacturing company, 326
Ferry-bridge, 423
Fire-fighting devices, 611, 612
-hydrants, 340
Fireproof buildings, 507
First United States railway, 231
Firth of Forth bridge, 414
Fish and oyster industry, 327
canning, 329, 330
preservation, 326
Flint-bottles, 497
Flint, Charles R., 162
Floating docks, 163
lady trick, 431, 433
Flooring-machine, 290
Flour-milling, 517–526
statistics, 517, 518, 526
Fluoroscope, 31
Flying-machines, 93–117
-shear, 83
Fog-horn plant, 272
signal apparatus, 271
Folding-machine, paper, 370, 371
Foods, 326–337
Forest preserves, 277
Foucault's experiment, 405, 406
Freight-cars, 247
elevators, 627, 628
locomotive, 230
traffic, 231
Fruit preservation, 334
Fuel-gas battery, 609
system, 443
Furnaces, 78, 79
Furniture trade, 579–582

G

Garbage disposition, 594, 597
reduction plant, 598, 599
Gas statistics, 267, 268, 269
-engines, 471–473
-holder, 266, 267
mantle, Welsbach, 258, 259
-scrubber, 266, 267
-tar, 292, 293
Gates, P. W., 450
Gelatin process, 356
Generators, electric, 19, 39
gas, 262–266
Ghost trick, 430, 431
Gigging-machine, 305, 308
Glass, cut, 500, 501
-cutting, 500
factory, first, 496
-making, 495–501
statistics, 496
Gluing-machine, 373
Glycerin, 592
Gold and silver money, 441
-mining, 293–301, 315
nugget, largest, 293, 294
production, 301, 445
Goodyear, Charles, 539
welt-machine, 536
Gordon, George P., 364

Grading-machine, 352
Grain consumption, 545
conveyors, 525
elevators, 524, 525
storage, 523, 524, 525
Gramophone, 407
Grand Central R. R. yard, 252
Granite business, 583
Graphophone, 407
Great Eastern, 164
Greth, Dr. August, 107
Gunboat Vermont, 189
Guns, 182–186
Gutenberg press, 354

H

Half-tone engravings, 382
process, 357, 360–362
Hand printing-presses, 377
Hard steel, 85
Harveyizing, 189
Havemeyer, 574
Heeling-machine, 536
Hertzian waves, 20
Hewitt, P. C., 35, 273
Hoe presses, 369
Holland submarine boat, 172, 178, 179
Hulling-machine, 328
Hungarian milling method, 520
Hurley, R. E., 249
Hydraulic cement, 514
dredge, 352
elevator, 627
shield, 204
Hydrogen sulphide, 564
Hyposcope, 192, 193

I

Ice-boats, 610
factories, 337
-machines, 334, 632, 633
manufacturing, 337, 633
statistics, 337
-tanks, 336
trade, natural, 334
Illustrations, 360–362
Incandescent light, 254, 257.
Incinerators, 597
Ingalls, Francis, 528
Ingot of steel, 88
Ingrain carpet, 620
Inking devices, 362
Institute of architects, 504
Instruments for the deaf, 409
scientific, 400–411
Iron bridge, first, 414
exports, 90
ore of United States, 72
Ironing-machine, 623
Irrigation canal, 195
Italian marble, 587

J

Japanned leather, 530
Jetties, Mississippi, 346
Job printing-presses, 364
Jubilee diamond, 314

K

Kaiser Wilhelm II, 166, 170
Kearsarge, 151
Kensett, Thomas, 326
Kern River oil-field, 565
Keyboards, 366
Kimberley mines, 292, 316, 317, 319
Kinetoscope, 409
Kites, man-supporting, 101
Klondike gold-mining, 299
Kneading-machine, 334
Koerting gas-engine, 473
Kohinoor diamond, 314
Kress, W., 114
Krupp, Alfred, 185

L

Lager beer, 547, 548
Lake Baikal, 236
ore traffic, 71
Landing-dog, 313
Langley, Professor S. P., 93
Langley's aerodrome, 112
Lanson's kite, 94, 102
Lanston monotype, 366, 367, 368
Lasting-machine, 535
Launching, new method, 149
Laundry machinery, 621–623
Leaching ore, 306

Lead-pencil industry, 618, 619
Leadville mines, 302
Leather industry, 527–537
census, 528, 529
Letter-cancelling machine, 612, 614
-press printing, 370
Lick telescope, 401
Life-saving apparatus, 606
Lift-bridge, Scherer, 422
Light-House Board, 269
projectors, 268
Lighthouses, 269–272
Lightning arrester, 48
Lilienthal, Dr. O., 94
Lima-Indiana oil-field, 561
Limestone, 587
Linotype, 364, 365, 380, 381, 385
Linseed oil, 623
Liquor manufacture, 543–549
Lithography, 369
Lixiviation process, 506
Locomobile, 28, 126
Locomotive, 223, 225, 230, 246, 247
construction, 247
statistics, 246
Locomotives, compound, 233
Logging-camps, 274, 276
London dailies, 384
Longwall mining, 322
Loom, 620
Loop-the-loop, 436
Louisiana sugar industry, 573
Lucania, 166
Luh Han railway, 236
Lumber flume, largest, 279
lands, 276–278
-mill, 283
statistics, 274
transportation, 275

M

Machine-guns, 191
-making, 449–460
oil paintings, 607, 608
Machinery for building, 508
statistics, 459, 460
Magazine illustrations, 360
pistol, 193
" Making ready," 364
Malleable iron, 87
Malt liquor, 545
Manchester canal, 197
Maple sugar, 576
Marage, Dr. R., 409
Marah, Sylvester, 245
Marble for building, 506, 507
variegated, 585
Marconi, 17, 50–52
Marconi's detector, 56
Marine engine, 165
Matrices, 364
Maxim, Hiram, 114
Maxim's flying machine, 111, 112
McKay's shoe machinery, 535
Meat packing, 330–332
preservation, 334
Meigs, Captain J. V., 228
Menai Straits bridge, 414
Mercerizing, 448
Mergenthaler, Ottmar, 364, 369
Middlings purifier, 519, 520, 522
Milling-machines, 450
systems, 520, 521
Mine-cage, 312
-hoisting machines, 310, 311
locomotive, 299
shafts, 292, 302
Mining anthracite coal, 321
by explosives, 321
locomotive, 320
statistics, 321
Minnesota, American steamship, 171, 172
Mint, 442–448
Mississippi jetties, 346
Mitchell farm, 209
Modelling machine, 604–606
Mond gas, 471, 472
Money manufacture, 441–448
Monoline machine, 368
Monorail roads, 226
Monotype machine, 366
Mont Cenis tunnel, 202
Mosher, Charles D., 162
Motors, 18, 68, 473–482
electric, 476, 477
Mount Washington railway, 245
Mountain railways, 245
Moving pictures, 436–440
stairway, 629
Myers, Carl E., 91

N

Nails, wire, 636
Natural gas, 80
Navies, 150
Nernst electric lamp, 259, 260
Newbold, Charles, 219
News agencies, 378
  gathering, 378
Newspaper advertising, 382
  circulations, 382
  history, 376–387
  illustrations, 381
  pictures, 360
  statistics, 376, 379
  telegraph service, 382
Newspapers, 376–384
New York subway, 240
Nile dams, 349, 350
Nitro-cellulose, 189
Nome gold output, 299
Norman, Henry, 118
Northrop loom, 488, 489

O

Oil certificates, 563
  -engines, 475, 476
  industry, 556–565
  painting, mechanical, 607, 608
  -wells, 556–558, 565
Oiled roads, 135–146
Oldsmobile, 127
Oleomargarine, 331, 592
Open-hearth furnaces, 78, 79
Ordnance statistics, 182, 183
Ore classifiers, 308
  -finding, 25
  freightage, 71, 231
Orling's wireless apparatus, 59
Oscillator, 54
Overhead bridges, 233
Oyster preservations, 326

P

Paints and varnishes, 623–625
Panama Canal, 198
  dredging, 346
Pape, H. G., 408
Paper-feeding machines, 374, 375
  -folding machines, 370, 371, 374
Paper, Japanese, 396, 397
  -making, 390, 396
  -money manufacture, 446–448
  -testing, 397–399
Papier-maché, 380
Paris dailies, 384
Parsons steam-turbine, 160, 468, 469
Pea-blanchers, 328
  -sieves, 328
Pennsylvania tunnel, 241
Petroleum, 556, 565
Phenakistoscope, 406
Phonautograph, 406
Phonograph, 383. 406–408
Photo-engraving, 355–360
Photograph, X-ray, 410, 411
Photography for printing, 359
Photophone, 22
Pictorial printing, 354–362
Pig iron, 74
Pike's Peak railway, 245
Pilatus railway, 246
Pilcher, Percy S., 95
Pintsch gas-lights, 271
Pistol, magazine, 173
Placer mining, 298
Planing-machines, 451
Plaster of Paris, 607
Plate-glass, 496, 499, 500, 501
  -matter, 382
Pneumatic tools, 456, 457
Polariscope, 574
Pontoon bridges, 424
Pork exports, 332
  -packing industry, 331
Port Arthur railway, 236
Portland cement, 508, 515, 516
Potato-planter, 220
Power producers, 461–482
Pressed-steel cars, 247, 248
Presses, cylinders, 362, 377, 379, 380
Pressing-machines, 457
Printing, 354–375
  -presses, 360, 362, 364–368
  telegraph, 26–28
Prismatic reflector, 357
Process-kettle for preserving, 326
Projector, 261, 268
Prospecting drill, 298
  shaft, 302
Pug-mill, 567

Pull-boats, 281
Pulp-grinder, 392, 394
Pumping-engines, 342
  stations, 340
  water, 340–342
Puppet theatre, 429, 430

Q

Quarry industry, 583–587

R

Rags, 590
Railway capitalization, 231
  electric, 225
  employees, 232
  fatalities, 231, 252
  mileage, 231
  signals, 251
  speed tests, 228, 229
  steel, 226, 232
  steepest in world, 246
  switches, 252
Railways, 223–253
Rapid-fire gun, 158, 183
Ready-mixed paints, 624
Reaping wheat, 209
Reflector, Crossley, 402, 403
Refrigeration, 336, 631, 634
Refuse, disposal of, 596
Register of fares, 614
Reichel, Herr Walter, 225
Reid, James, 609
Resawing machines, 286, 287, 290
Reservoir system, 342
Rhodes, Cecil, 237
Rice-growing, 210
Richet, M., 114
Rifles, 191, 192
Riveting-machine, 632
Road-making, 139–146
  -roller, 139
Roasting furnace, 306
Rochester flour-mills, 517
Rock-drills, 201
Roentgen, 410
Roller flour-mill, 519
Rolling lift-bridge, 421
  -mills, 82
Romanesque furniture, 581
Rotary engines, 463–465
  presses, 362, 377, 379, 380
Rubber manufacture, 538–542

S

"Saddleback" railway, 228
Salmon canning, 329
  fishing, 329
Sand-pump, 296, 297, 308
Sanding-machine, 289
Sandy Hook gun, 184
Santos Dumon No. 6, 105
Santos Dumont No. 10, 92
Sardine canning, 329
Satin weave, 490
Sault Ste. Marie Canal, 196
Saw-bench, 288, 291
Sawdust, 588, 589
Sawing-machines, 284–288
Saw-mills, 283
Scalding kettles, 328
Scalper, 521
Scherer, William, 421
Scientific instruments, 400–411
Scott, Leon, 406
Scrap iron and steel, 590
Screens for sizing ore, 307, 308
Screw-threads, 450
Scrubbing-machine, 530
Sculpturing, mechanical, 602–607
Scutching-machines, 488
Searchlights, 259, 261
Selective converter, 35, 273
Selenium, 21, 22, 24
Semaphores, 251
Serpollet steam motor, 136
Service-pipes, 341, 342
Shamrock III, 148
Shaw, A. J., 458, 615
Shearing-machine, 457
Shipbuilding statistics, 148
Shoe census, 1900, 536
  industry, 533
  machinery, 530, 534, 535
Shoemaking, 532–534
Shoe-pegs, 534
Siberian railway, 234
Siemens-Halske motors, 226
Silk industry, 483, 484, 485, 493, 494
  -mills, 485, 486

Silk statistics, 493
taffetas, 493
Silver money, 301–306
production, 444, 445
Simplon tunnel, 202
Skidding lumber, 280
Sky-scraper, 516
Slag cement, 509, 514, 515
Slate-picking, 325
quarrying, 583, 584
separators, 325
Slaughter-house waste, 392
Slaughter-houses, 330
Slime-table, 304, 308
Slushing process, 323
Smith, Alexander, 620
Smokeless powder, 188
Smoke-stacks, 610
Smyrna rugs, 620
Smyth book-making machines, 371
Snuff trade, 554
Soaking pits, 80
Soaring machines, 94–96
Soft steel, 85
Soldering cans, 328
Sorghum syrup, 577
South African railways, 237, 238
South American railways, 234
Speaking arc, 22
Spectroscope, wonders of, 404
Spectroscopy, 403, 404
Spindle, 488
Spindle-top Oil Pool, 563
Spinning-mule, 488
Sprague carpet factory, 619
Spreckels, Claus, 574
Springfield rifle, 191
Spring mattress, 579
St. Gothard tunnel, 202
Stage tricks, 432–434
Stamping-press, 442
Stand-pipe, 341
Starching-machine, 622
State roads, 45
Steam, 461, 462
-boilers, 257
-cooking, 328
-engines, 165, 461–480, 561
engineering, 466–471
-plow, 213
-pump, 336, 343
Steam railways, 223
-shovels, 352, 525
-turbine, 160, 470
-yachts, 162
Steamships, steel, 148
Steel and iron, 67
buildings, 248, 509, 514
freight cars, 247
-making, 65–87
rails, 226, 232
tempering, 81
Stereotyping, 379, 382
Stevenson, 230
Stewart, A., 574
Stock Exchange, New York, 505
Stone's wireless system, 60
Stoping in South Africa, 316
Storage battery, 45
tanks, 515
Stringfellow, 110
Structural steel, 82
Submarine mine, 175, 176
torpedo-boat, 172–178
Subsurface torpedo-boat, 179
Subway, New York, 206
Suez Canal, 195
Sugar manufacture, 573–578
-refining, 574–576
Sunday newspapers, 379, 382
Sun-motors, 481, 482
Superheaters, 257
Surfacing machine, 289
Surveying coal lands, 325
Suspended railways, 244
Swing-saw, 286, 291
Switchboard, electric, 255, 256

T

Talking casts, 409
Tannage, 531
Tanning industry, 527, 528, 531, 532
machinery, 530–532
Taylor, Allen, 326
Telegraphone, 37
Telegraphy, 25
wireless, 50–61
Telephone for farms, 221, 222
Telescope, 401–403
Telpherage, 630